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TEXTILE FIBERS UNDER THE MICROSCOPE.

The object of this paper is to illustrate more clearly and

investigations were begun, a month ago, the leading scientists and manufacturers of Belgium began a line almost precisely similar, and insisted on the necessity of a scientific

what the silk fiber is, and how to handle it in order to make it as valuable as the silks of Italy or France.

The fiber of silk as produced in the cocoon is a single,



FIG. 1.—TSATLEES.



FIG. 4.—ORGANZINE.



FIG. 7.—SATIN DE LYON.

definitely than has yet been done, the distinctive characteristics of the leading textile fibers—silk, wool, and cotton particularly—taking silk first in order because of the great degree of interest now shown in the growing of silk, as well

definition of the leading fibers, by precisely the same methods as we here employ.

Silk is at this moment a prominent object of attention, in consequence of the energy and spirit shown by our manu-

continuous, and perfect fiber—the most perfect and durable of fibers, if properly treated; and it must be treated as a single fiber throughout. *Raw silk* is a definite number, five to eight fibers, as reeled from the cocoons, and adhering in



FIG. 2.—FLOSS.

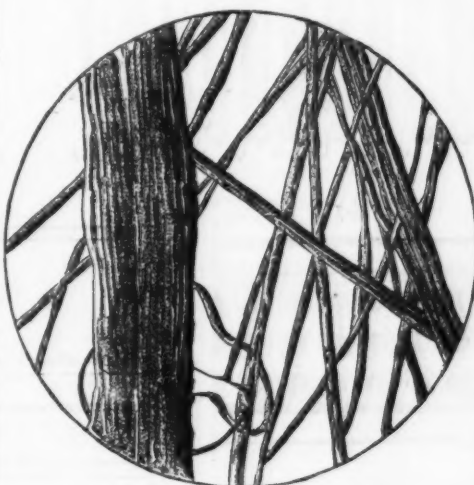


FIG. 5.—IMPERFECTLY REELED.



FIG. 8.—WOOL.

as its manufacture. The industries in cotton and wool have grown to vast proportions, and have made the country independent; silk is now growing to an equal place, and is already third, at least, in the United States.

facturers, and of the generous and most effective efforts of the Women's Silk Culture Association. Hundreds of families are induced to attempt the growing of silk, who cannot readily communicate with skilled workmen, or procure

a body by the gum of the cocoon remaining on them—apparently a single fiber, but really a bundle of eight, as shown in the figure, representing a thread of Chinese *Tsatlees* (Fig. 1), the best of the Chinese raw silks.



FIG. 3.—TRAM.



FIG. 6.—PONGEE.

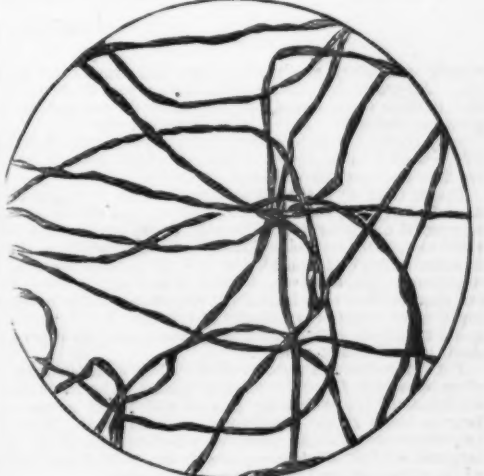


FIG. 9.—COTTON.

It is not usually supposed that microscopic investigations are needed in considering the uses and values of textile fibers, but it is a striking coincidence that at the time these

sufficiently full guides to their work. I do not propose to repeat the admirable general directions of the Ladies' Association, but I propose to show, with microscopic accuracy,

All silk fibers must be reeled in bundles of not less than five nor more than eight; if in single, double, or triple fibers, from as many cocoons, they can not be used as regular silk.

Floss silk (Fig. 2) is of two kinds: first, the light outer fibers of the cocoon, with the broken and imperfect fibers cleaned of gum, usually; but the better *floss silk* is reeled silk of not less than five cocoon fibers, not usually cleaned of gum, and not much twisted. This is more frequently called *singles*.

Tram (Fig. 3) is a combination of three threads, fifteen to twenty-four original fibers, with more twist, two and a half to three turns to the inch.

Organsine (Fig. 4) is made up of two threads twisted twelve turns per inch to the left, then doubled with eight turns per inch to the right. This is the standard quality of thread for the best silk goods.

All who reel silk should weigh five hundred yards of the raw thread, made up of five single cocoon fibers, making two thousand five hundred yards of single fiber. If the hank so reeled is above or below the standard weight, a greater or less number of cocoons should be united in the one raw thread.

These definitions are given because they are absolutely essential to success on the part of the American grower. He cannot make anything but raw silk in the gum, as reeled in the manner described; but he must know what the manufacturer who makes floss, tram, and organsine demands—for his silk will be worth but one or two dollars per pound, when it should be worth six dollars per pound.

Spun silk is made from pierced cocoons, cocoon waste, and the waste of mills using raw silk—that is, in its best form. It is carded and drawn with as much care as worsted wool, and forms a valuable element of many fabrics, parti-

nifier of one hundred and seventy diameters still leaves room for a good many on a space of one thirty-second part of an inch. Wool is an extremely valuable and interesting fiber, easily distinguished from any other fiber that may be spun with it.

The fiber of cotton (Fig. 9) is flat and plain, spirally half-twisted, soft, and porous, wholly distinct from either wool or silk, is easily dyed and easily drawn or combed when the fiber is long enough. As the fiber is very small, it can be spun very fine alone, but it does not work to advantage with either silk or wool.

The fibers of flax, jute, hemp, and ramie are quite different from those before named. They are hard and woody, only slightly cellular, and, while very valuable for various purposes, they cannot be spun with anything else to advantage. They are always flat, thin, and quite distinct in form from silk or wool when shown under the microscope. Ramie is believed to possess better qualities than flax or jute for mixing with silk, but it is still very doubtful whether the expectations on this point will be realized. So far they have not been. None of the woody fibers take dyes well, and they should never be mixed with the animal fibers in fine fabrics. The microscope alone is able to discover or to show positively the presence of these injurious mixtures after the fabrics are made up and dyed.—*Textile Record*.

FRENCH CANDLE-MOULDING MACHINES.

At the inception of the stearine industry, the apparatus for candle manufacture consisted of a series of moulds, in

two principles upon which are based at the present time the construction of the two sorts of apparatus now employed for moulding candles. One of these principles is that of an apparatus for grasping the wick at the butt of the candles in such a way as to center properly, and to afterward lift, in one piece, the candle and the solid mass at its base out of the mould. The other principle is that of the piston, by means of which, at a single upward thrust, the candles are ejected from the moulds containing them.

Of these two principles, the latter was the first to be applied practically, and since 1850 piston machines have been in general use in England. These machines, however, were not designed for moulding stearine candles properly so called, but rather for the manufacture of those of softer material, such as distilled palm oil, or coconut oil simply pressed. The manufacturers of white and hard candles from the products of the lime saponification of fat (the only kind of candles that were then found in the French market) did not employ these apparatus, and the attention of French inventors was turned rather to the production of machines on the other principle, in which the candle was to be drawn out instead of pushed out of the mould. The construction of apparatus based on this principle, however, was at first found to be beset with many difficulties, the principal one of these being the proper form to be given the device for fixing the wick, centering it, and furnishing a point of attachment to the apparatus for extracting the solidified candles. All efforts in this direction, up to the year 1856, remained unsatisfactory and without result; but finally, after a lengthy series of experiments, the problem was

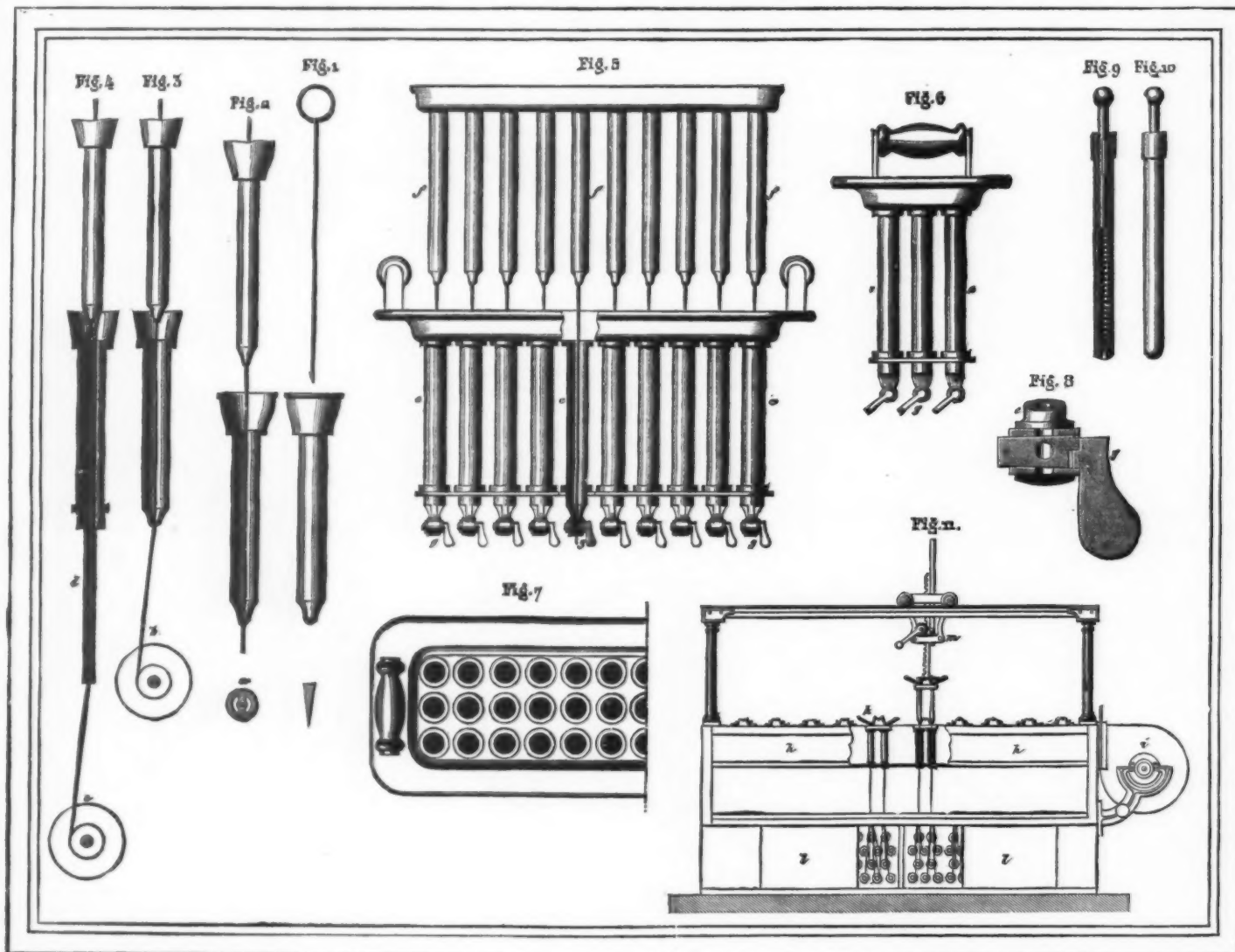


PLATE I.—MORANE'S CANDLE-MOULDING MACHINES

cularly upholstery goods, trimmings, and ornamental articles. All growers will, of course, have a part of their product in these waste forms, but they alone do not make silk-growing profitable. Fig. 5 is imperfectly reeled.

I say nothing of the conditions of growing and preparing silk beyond what is necessary to that definite knowledge of the fiber itself, which will prove its value.

Pongee (Fig. 6) is a peculiar fiber, of Chinese origin and manufacture, flat, like the fiber of cotton, and ribbon-like in its general character. Considerable doubt hangs about the exact methods of its production in the form in which we find it, some authorities considering it as a true silk fiber. The microscopic test, however, shows it as lacking the one essential characteristic of animal fibers, roundness, and as possessing the one essential peculiarity of vegetable fibers, flatness, and a manifestly cellular structure, thus leaving no room for doubt on this point at least.

Fig. 7 represents a number of silk fibers as taken from a piece of *satin de Lyon* of the higher grades. The fibers show evidences of the weighting process which has become so large a factor in the preparation of these goods. The excrescences are adhering particles, which, as well as the enlargements of the fibers, are probably due to local accretions of the chemicals used in the process of dyeing.

Wool (Fig. 8) is a round, perfect, continuous fiber, translucent, and, like silk, easily penetrated with dyes. Combining brings the fibers together in a bundle, nearly parallel, and, by twisting, they felt or adhere by their slightly roughened surfaces. But wool fibers are, on an average, three or four times as large as silk fibers, except for superfine, which is not more than twice as large as silk. A mag-

nifier of one hundred and seventy diameters still leaves room for a good many on a space of one thirty-second part of an inch. Wool is an extremely valuable and interesting fiber, easily distinguished from any other fiber that may be spun with it. The fiber of cotton (Fig. 9) is flat and plain, spirally half-twisted, soft, and porous, wholly distinct from either wool or silk, is easily dyed and easily drawn or combed when the fiber is long enough. As the fiber is very small, it can be spun very fine alone, but it does not work to advantage with either silk or wool. The fibers of flax, jute, hemp, and ramie are quite different from those before named. They are hard and woody, only slightly cellular, and, while very valuable for various purposes, they cannot be spun with anything else to advantage. They are always flat, thin, and quite distinct in form from silk or wool when shown under the microscope. Ramie is believed to possess better qualities than flax or jute for mixing with silk, but it is still very doubtful whether the expectations on this point will be realized. So far they have not been. None of the woody fibers take dyes well, and they should never be mixed with the animal fibers in fine fabrics. The microscope alone is able to discover or to show positively the presence of these injurious mixtures after the fabrics are made up and dyed.—*Textile Record*.

At the inception of the stearine industry, the apparatus for candle manufacture consisted of a series of moulds, in

which the wick, fixed at the lower end by a small wooden plug or wedge, was centered at the top of the mould by means of a tin disk perforated in the middle, and to which it was secured by a knob. Work with apparatus of this kind was tedious, slow, and troublesome; yet up to the year 1848 this was the only kind in use. At this date, Cahouet, the founder of the present house of Paul Morane, senior, of Paris, introduced for the first time an apparatus on a greatly improved plan. To render the moulding of the candles and their removal from the moulds more rapid, Cahouet directed his efforts toward securing a grouping together of the moulds and doing away with the plugs. With this end in view, he made his new apparatus in the form of a trough, having 16 to 30 apertures in the bottom, and into which were screwed the butt ends of the moulds. To the lower end of each of the moulds he adapted a bronze cock, which was traversed by the wick, and by turning which the latter was held securely in place and afterwards cut—two operations which had formerly been effected by the plug and a pair of scissors. This form of apparatus was in use up to 1856. In the meanwhile, different inventors had been at work on an improved form of apparatus, and had directed their efforts toward devising a machine in which the cocks could be dispensed with, the cottoning be done mechanically instead of by hand, and in which the moulds might, without removal, be heated before moulding and cooled afterwards—a machine, in fact, so arranged that as soon as the candles had been ejected from the moulds another batch could be at once proceeded with without loss of time.

It is a remarkable fact that in the patents of these different inventors there are seen to appear simultaneously the solved by Paul Morane, senior, in the production of an apparatus which has now been in use for twenty years with but slight modification of the original pattern. The merits of this machine were quickly appreciated by the manufacturers of stearine candles, and it soon came into use throughout Belgium, England, Holland, Germany, etc. The apparatus consists of a cast-iron frame, at the base of which there are parallel rows of cotton bobbins, which revolve on strong pins. Generally, each frame carries two hundred of these bobbins, each wound with 225 feet of wicking—that is, enough for 300 candles. The moulding apparatus is composed of a series of ten mould supports, each having twenty moulds. These are either inclosed in one box, when it is desired to heat by steam and cool by water, or in as many independent boxes, when it is proposed to heat or cool by water alone. Above each mould support is located the device which is in reality the essential part of the machine—that is, the wick-holder. This is composed of two parts: first, the part for centering the wicks, consisting of a straight edge provided with notches, through which pass the wicks after traversing the moulds; second, of a hollow rule, likewise notched, and within which moves parallel with it a notched copper slide. The latter is moved by means of a lever, and its object is to gripe the wicks and fix them in the center of the mould. This part of the apparatus is likewise provided with clasps, by means of which it may be attached to a rack and pinion jack which rolls along the top of the frame, and the object of which is to lift the wick-holder along with the solidified candles. To give some idea of the economical results obtained by the use of this machine, it is only necessary to state that with it 400 candles

per hour may be manufactured, while the number produced by the use of hand moulds never exceeded 60 or 70 per hour.

This machine, however, is not adapted to the production of candles from soft materials, owing to the liability of the wick slipping through the candles and leaving the latter in the mould when an effort is made to draw them out. The gradual adoption of the distillation process in France made it necessary, therefore, to devise apparatus based on the other system to which we have referred. As all the machines in use had serious defects, Mr. Morane applied himself to the production of an apparatus which should prove a model of a perfect moulding machine on the piston principle; and finally, in 1871, he brought out such an apparatus and called it the centering machine. This is a much smaller machine than the one just described, and is provided with from 30 to 60 moulds only. The mould supports and the box in which the moulds are inclosed are supported in a light, oblong cast-iron frame. The moulds, which are cylinders simply, are secured at their upper extremity to the mould support, and at their lower to the bottom of the box, and are so arranged that the pistons can traverse them freely from top to bottom. The pistons, which are hollow tubes, having a matrix in the form of the head of the candle soldered to their upper extremity, are fastened to a movable bed, which is raised and lowered by means of bevel wheels and screw and a crank handle. The bobbins are located at the sides of the machine, so as to be under the eye of the workman. The machine is provided with an ingenious arrangement, by means of which the candles are clamped as soon as they are ejected from the mould, and held in an exactly vertical position, so that the centering of the consecutive portions of the wick is perfect.

comes possible to mould four batches per hour, while with the former style of machine, in which the candles were drawn out of the mould, three quarters of an hour were necessary for the moulding, cooling, and extraction of the material.

This invention, then, not only effects a diminution in the cost of candles, but affords a product of superior quality, and from this point of view is worthy of the greatest interest.

EXPLANATION OF THE PLATES.—(The same letters designate corresponding parts throughout.) Plate I., Fig. 1, cup mould with hooked needle for seizing the wick, and wooden plug for fixing the latter at the bottom of the mould. Fig. 2, section of mould, the candle being ejected; *a*, a tin disk perforated in the center for the passage of the wick, and having apertures for the passage of the melted fat. The disk is placed at the bottom of the cup, and is kept in place there by the knotted wick.

Fig. 3, section of mould, with ejected candle; *b*, the bobbin around which the wick is wound.

Fig. 4, section of piston mould; *c*, the bobbin; *d*, the tubular piston.

Fig. 5, front view of a mould support; *e*, *e*, moulds, one of which is in section to show the passage of the wick and the construction of the cock; *g*; *g*, candles.

Fig. 6, end view of Fig. 5.

Fig. 7, plan view of the same.

Fig. 8, section of a cock, *g*, which serves for closing the lower orifice of the mould, and holding and cutting the wick.

Figs. 9 and 10, exterior view and section of an apparatus for cottoning the moulds by hand.

Fig. 11, front view of Morane's continuous cottoning

STRAW AND STRAW GOODS IN TUSCANY.

For centuries the manufacture of straw hats has been a special art in Tuscany, and Signa, one of the most industrious of Tuscan towns, was for a long time the center of the trade, which, however, was of little importance and limited until the seventeenth century, when it commenced to attract considerable attention, and large quantities were manufactured both for home use and for exportation. There are three varieties of wheat of the golden plant (*planta della fila d'oro*), as straw is called in Tuscany, the first is called "Pontederas semone," which produces the best straw for hats; the second, "Marzuolo," which is of a rather common quality; and the "Santa Fiore," which is only used for pedals and braids. The Pontederas semone is sown in arid soil, while the other two varieties require a more fertile soil. Seed is sown in November and December, according to the season, the object being to have the grain well up before the heavy frosts come, in the proportion of eleven hectoliters to each hectare, that is, about 13½ bushels to the acre. It is sown as thickly as possible, in order that the growth of the plant may be so impoverished as to produce a thin stalk, at the same time having toward the end from the last knot the lightest and longest straw. Side hills, with a gravelly soil, and high meadow lands that have had a surface plowing and rough harrowing, are specially adapted to the straw culture, low, swampy grounds being generally avoided, as dampness, when the stalk is well grown, renders the straw discolored and coarse. The ground is plowed and dug up in June, and left in this condition until November, when the soil is again turned up, and then it is ready for sowing. If the soil is very poor and thin, a very light surface of

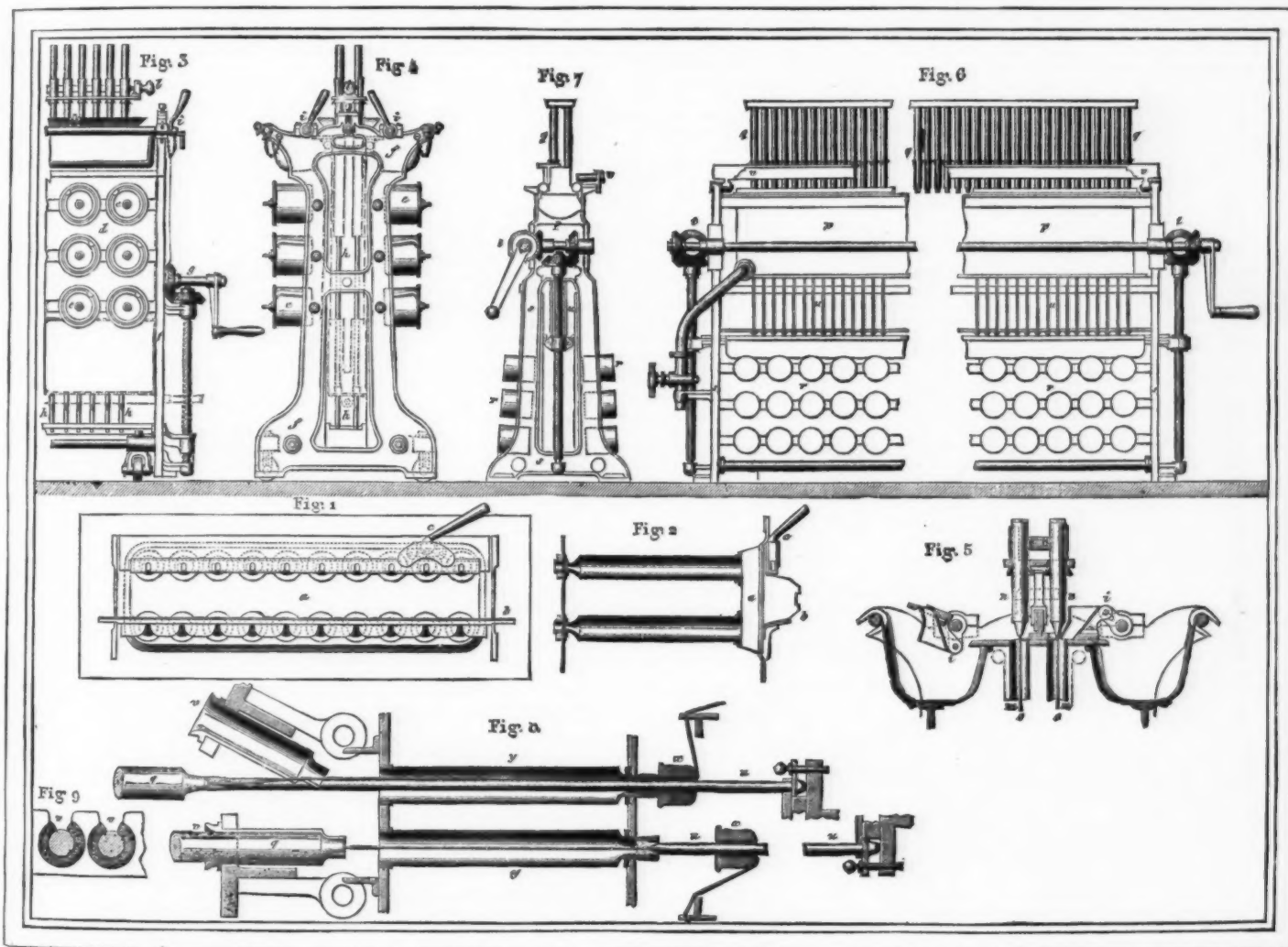


PLATE II.—MORANE'S CANDLE-MOULDING MACHINES

The success which this machine met in France and foreign countries led Mr. Morane to apply the same system to the moulding of hard materials derived from lime saponification, which he did three years since, in the construction of a machine which he styled the "Parisienne." The general principle on which this new apparatus is constructed is about the same as that of the machine just described, certain modifications of detail constituting the only difference; but these modifications are of vital importance. They are such, in fact, as to permit of the candle being ejected while the outer surface only is hard and the inner portion is still in a liquid state. To obtain this result, Mr. Morane has substituted for the piston head which moulded the top of the candle, a small piece of bronze, which forms merely the extreme tip of the candle, and which, serving as a support, suffices, when the material is hard enough, to eject the half-solidified candle. He has also substituted for the movable clamps which served to keep the candle in place, movable cups, which being turned outward when the candle is ejected, allow it a free passage, but afterward being turned back in place serve as a support for it and hold it vertically until the wick is to be cut. Owing to this arrangement it becomes easy to eject at the same instant the entire lot of moulded candles while they are as yet in a liquid state in the middle. Ten minutes, or fifteen at the most, are sufficient to give the mass a solidity such that the candles can be thus ejected without any danger of crushing them, and the workman can consequently proceed to mould a new batch every ten or fifteen minutes. Ten or fifteen minutes' exposure to the air is sufficient to solidify the candles completely. With this new machine, then, moulding candles from hard materials may be effected as rapidly as it can from soft ones; and it now be-

manuring is occasionally used, but this is not frequently resorted to, as it is apt to render the stalk thin and brittle. The wheat blooms at the end of May or beginning of June; it is generally pulled out by hand by the roots when the grain is half developed. For uprooting the straw, fine continued sunny weather is selected, as the rain has a very injurious effect upon it, often turning it black. When uprooted, the branches are tied together in sheaves, each sheaf, or "menata," is spread out in the shape of a fan to dry in the sun from three to five days, after which it is stowed away in barns. The harvest being over, and the fields being only in stubble, the straw is again spread out to catch the heavy summer dews, and to bleach in the sun for four or five days, but not the whole of the crop at the same time for fear of a sudden rain. During this process it is carefully turned until all sides are equally white. Formerly the yellow color of the straw was preferred, but now the extra white is more sought after. Before being ready to be made up into braids, hats, and ornaments, the straw has to be again bleached, fastened in small bundles, and classified. It is then cut close above the first joint from the top, and again tied up in small bundles containing about sixty stalks in each. These small sheaves are then submerged in clear water for four or five minutes, and as soon as they become partially dried, are submitted to the action of burnt sulphur (in the proportions of one pound to one hundred bundles of straw) for three or four nights, in rooms adapted for the purpose; during the day the doors of these rooms are left open. The classification of the straw is made according to length and color, the ear or end of the stalk having been previously cut off; all the straw below the first knot is used simply for forage or bedding, as it is worthless for the purpose of making braids or hats.

Fig. 1, plan view of a compartment of the machine, figured No. 11, in Plate I—*a*, the mould supports; *b*, the centering square; *c*, the wick-holders seen at *k* in Fig. 11, Plate I.

Fig. 2, end view in section of the moulds and wick-holder.

Fig. 3, front view of the centering machine; *d*, the mould box; *e*, *e*, the bobbins; *f*, the frame; *g*, crank handle, bevel wheels, etc., for raising the piston-bed; *h*, the pistons; *i*, the centerers; *l*, the movable clamps for holding the finished candles.

Fig. 4, end view of centering machine.

Fig. 5, view of the upper part of the same, on a larger scale; *m*, *m*, the moulds; *n*, *n*, the rejected candles; *o*, *o*, wicks; *i*, *i*, the centerers.

Fig. 6, front view of the machine called the "Parisienne"; *p*, mould boxes; *q*, ejected candles; *r*, bobbins and wicks; *s*, the frame; *t*, crank, etc., for raising the mould bed; *u*, the pistons; *v*, receptacles for the finished candles and wick centerers.

Fig. 7, end view, showing one of the receptacles turned outward to allow the candle to pass.

Fig. 8, section of the upper part of the machine on a larger scale; *y*, the moulds; *g*, *g*, the candles; *u*, *u*, the pistons; *v*, *v*, the centering candle-holders; *z*, *z*, counterpoises, to keep the wick stretched.

Fig. 9, plan view of the centering candle-holders.

There are no factories, says the United States Consul at Florence, for working up straw, but in almost every private dwelling of the lower classes will be found one or more of the female inmates attending to her domestic duties, and at the same time making braids and sewing on hats. A ready sale is found for their work at the nearest market, though, in many instances, special contracts are made by the "fattores" (straw brokers) with the workwomen directly, they supplying the straws into which the braids are made up. Many women make from 28 to 34 yards of braids a day, and some can finish even 60 yards of common braids, but fine braids require very great care and cleanliness. Owing to the great strain upon the eyes, the finer kinds of braids can only be worked upon from two or three hours each day; it takes, therefore, a woman from four to five days to make braid sufficient for the hats usually worn by men, while for the superior Leghorn hats for ladies it requires from five to nine months for each hat. It is a noticeable fact that, in several districts where the finer hats are made, the workwomen suffer greatly from affection of the eyes, caused by too close application to this kind of labor. Between 1822 and 1826, women employed in making braids realized from 6s. to 7s. a day, but at the present time the best braid-makers and hat-sewers only make about 1s. The most important centers of the straw industry are Brozzi, Signa, Prato, Fiesole, the Casentino, the Bolognese, and the Modenese. The province of Casentino is one of the most industrious in Tuscany, producing from 300,000 to 400,000 hats yearly, all for exportation. These hats, though hitherto comparatively unknown, are now very much sought after, on account of their strength and cheapness, prices varying from 4d. to 1s. each. In the Bolognese, the straw manufacture is confined chiefly to the mountain districts along the base of the Apennines, where the inhabitants of seventeen parishes are engaged in making the cheaper and coarser kinds. Laino and Searicalasino are the center of this trade. Bolognese hats are brought to Florence to be fashioned, and the price paid is from 1s. 6d. to 2s. 6d. per dozen, and the quantity brought amounts to about 120,000 dozen yearly. For the last thirty years the annual exportation of straw goods from Tuscany averaged 12,000,000 lire, 5,000,000 lire alone being exported to the United States in 1878. By a comparison of the three principal products annually exported from Tuscany, straw goods show a value of 12,000,000 lire; silk, 5,000,000 lire, and timber, 4,000,000 lire.

NEW DISCOVERY REGARDING GELATINE EMULSION.

By L. WARNERKE.*

SOME short time ago, when investigating the nature of the photographic image developed on gelatine plates, I observed that the portion of the gelatine emulsion submitted to the combined action of light and the developer became insoluble in warm water.

The discovery of this new principle led me to make numerous applications of it. Gelatino-bromide emulsion in my hands proved useful in every branch of photography, and in my communication to-night I intend to make you acquainted with the broad principle as well as with a general outline of its applicability to various ramifications of the photographic art.

The first and the most important application will be to negative-making generally. I proceed in the following manner:

A sheet of paper is covered by the ordinary gelatine emulsion and dried. A precaution to be observed is, that the coating of the emulsion must be uniformly homogeneous, and when the sheet is dry that it remains flat. This paper is to be used, instead of a glass plate, in the camera—in fact, in all cases where sensitive plates are used for obtaining negatives or positives. The exposure is in accordance with the sensitiveness of the emulsion, but it remains strictly the same whether the emulsion is spread on glass or on the paper. The exposed sheet of gelatinized paper is next developed with alkaline pyrogallol development, exactly in the same manner as with the glass plate. After development it may be fixed, or it may not; then it is preferably dried. Insolubility of the developed portion is produced as soon as the image is fully developed, but it is not so complete while the film is still wet. The same is the case with the action of alum on gelatine, and for this reason it is advisable to dry the image before the next stage of the process, which consists in removing by solution in hot water all parts of the emulsion film not acted upon by light and the developer, and which consequently remain soluble in warm water. The action of light and the developer penetrates into the thickness of the film more or less in various parts of the image, according to the intensity of the light. It follows from this that under the insoluble portion of the image there may still remain some gelatine not reached by the light and the developer, and consequently soluble. It would be, therefore, useless to put the sheet bearing the image in warm water just as it was developed, because the image, also insoluble, would be "under-washed" and beyond possibility of recovering.

This explanation is only necessary for the very few not acquainted with the principles and practice of the carbon process. In reality, from this point I follow exactly all the rules of the carbon process—that is, the gelatine surface of the paper bearing the image must be cemented to some impervious material and washed from the back or paper side until all soluble gelatine is removed.

Now what impervious material is to be chosen? This choice depends upon the destination of the developing image. In the case of negatives, glass is very convenient, and it may be used without any preparation, or it may be collodionized or varnished with gum-dammar or other varnish, or waxed.

Cementing the image is produced by putting the gelatine surface in contact with the support under water, and removing with a squeegee all superfluous water; when unprepared glass is used, it is advisable to leave the image there until it is dry; in all other cases, only for a few minutes.

Next the glass, with the paper cemented to it, is plunged into warm water, and very soon the paper which is thus loosened can be stripped off and all the soluble gelatine washed away, leaving only the insoluble portion forming the image. This is washed in cold water, and the negative is finished.

It will be observed that this negative, when used for ordinary silver printing, will give reversed images. This can be obviated by several means; by cementing the developed image to transfer paper, which is made by rendering the paper waterproof and greased on the surface (an excellent paper of this description is supplied by the Autotype Company under the name of "flexible support"), and when the

image is finished to transfer it to glass, on which it will remain permanently, or by using a paper bearing a film formed of collodion or insoluble gelatine, or a combination of the two. In this case the image will be produced on the film, the paper being stripped off by rubbing turpentine on it, as was indicated by myself for my sensitive negative tissue; the printing in this case can be done from either side.

Lastly the image can be developed on the collodionized glass, the glass being first rubbed with talc; it can then be backed with my previously described film tissue, or with a sheet of gelatine, or the film can be made by coatings of collodion or gelatine, and, when dry, stripped. By either of these methods the negative can be reversed without any difficulty, but for myself I prefer to have it on the film, and this can be produced of sufficient thickness to form not only the substitute, but also the nearest approach in appearance to glass.

Now, when the method of obtaining negatives by this new system is explained, the question can be put, What advantage is gained? I reply, the advantages are many and important. With the certain quality of the emulsion on the glass, when compared with the same on the paper, the result is easier to obtain and it is of superior quality on the paper.

Everybody who uses gelatine plates—and who does not use them now?—is familiar with the difficulty in estimating the exact exposure, and frequent failures are produced by over-exposure. Only a correctly timed exposure will give a negative possessing vigor and brilliancy; a slight over-exposure gives an image flat, weak, and veiled; this is the natural drawback of glass plates; it was known in the collodion time, but only the superior sensitiveness of gelatine made us fully acquainted with it. The very same gelatine emulsion on the paper does not produce the evil effects of over-exposure just described. This assertion is too important to advance without proving it by actual experiment. There is here a sheet of paper covered with gelatine emulsion, and a glass plate covered also with the very same batch of emulsion. In this black and opaque paper I cut holes, and by putting these simply made negatives, one in contact with the paper, and the other in contact with the glass, I give very long exposure to the light. The image is visible in both cases. Next I develop the paper and the glass simultaneously in one dish. The developer is purposely made very weak and well restrained in order to have the image coming up as slowly as possible.

Let us now watch attentively the behavior of the two negatives. On the glass plate, at first, the image appears black, as normally it ought to be; but very soon we begin to observe that the portion of the plate totally protected from light by the opaque part of the black paper begins to blacken, forming a halo round every figure developed normally; this halo extends more and more as the developing continues. But, lo! another change. The originally black image has turned into a white one, while the halo extends to almost the whole of the plate, and now the reversal of the image is complete. Meantime the paper film image is free from blurring halo, and also is not reversed. Exactly the same happens when negatives are taken in the camera. Over-exposure produces blurring and fogging of the plate; this produces flatness; but if the over-exposure is continued, partial and even total reversal of the image takes place.

What is the cause of these striking phenomena? A complete explanation can be made of halation and blurring, viz., the light acting on the gelatine surface penetrates it, and, being reflected from the back of the glass as well as being dispersed through the thickness of the glass, acts on the sensitive surface from the back, and hence the phenomena observed.

As regards the reversal of the image, I confess I am not clear as to the cause why it does not take place on paper, and I hope that Captain Abney, who has studied this question, will be able to fill the gap caused by my ignorance. However, I take this opportunity to place before you the facts gathered during my investigation. I believe that the reversal of the image on the glass is due to the following reaction:

By the action of light part of the bromine forming bromide of silver is liberated. When the image is developed, in the first instance, it has a normal appearance; but the water of the developer subsequently forms hydrobromic acid with the liberated bromine, and this acting on the previously precipitated silver, forms again bromide of silver, which, dissolved in the fixing solution, is the reason of the reversal of the image.

Apparently, the very same reaction must take place in the paper negative. However, from the different definite result, I had doubts about it, until, upon making experiments similar to the one just described, the following incident happened:

One of the persons present, by mistake, opened the printing frame in the light, and this caused a small amount of light to act on the whole surface of the paper. In developing, that naturally produced general fog all over the plate. When the development was almost over, the fogged sheet was kept inclined during examination, when, to our astonishment, the fog began to clear up, and this in such a manner as if some clearing solution was exuding from the developed parts only, and running in the direction commanded by the incline of the sheet of paper. This incident, purposely produced several times afterwards, taught me that on paper, as on glass, the bromine liberated by light forms hydrobromic acid with the water of developer; but why it does not act on the developed image in the same way in the case of a glass support I am not able to account for.

Greater latitude in the exposure is not the only advantage gained by the new process; there is one more important still. Since gelatine plates came into general use, lowering of the standard of excellence has been observed in the results obtained; the last Exhibition, according to competent authority, is an illustration of this assertion. Equally good authority has found the reason of this in the impossibility to intensify satisfactorily gelatine negatives. I do not mean to insinuate that gelatine cannot give an intense negative—just the reverse; but the best negative by the wet collodion process is generally produced when the first developed image is not sufficiently intense, but is subsequently brought to its final condition by intensification.

This mode of procedure, desirable also in the case of gelatino, cannot be resorted to, owing to the impossibility of intensifying these negatives satisfactorily, because silver intensification stains the film all over, while the only available mercurial intensifications are to be discarded for different reasons.

Negatives produced by the process just described have no gelatine to be stained, and consequently are quite as fit for silver intensification as the old-fashioned wet collodion. They permit also the application of several other systems of intensification not yet known; viz., when the negative is quite finished, and on the plain glass surface, the application

of any soluble coloring liquid stains the image a corresponding color, the intensity of which is in proportion to the thickness of the gelatine, and consequently in proportion to the action of the light. Very beautiful results can by these means be produced for other purposes than intensification, viz., for chromo-transparency, and they are especially very pretty for the optical lantern or the stereoscope. It is remarkable that, if the developed image is not very intense, the colored image has the appearance as if it were formed entirely from the color used, to the exclusion of the color of precipitated silver.

There is still another mode of changing the color of a developed image. I found that there are many substances that can be mixed with gelatine emulsion without producing any action on the quality or sensitiveness. If ordinary water or moist color is ground up in the emulsion, the developed image will retain all this color, while in other portions it will dissolve together with the gelatine containing it. By this means a great variety of color in the image can be produced, some of very pleasing effects, closely resembling the silver-albumen print, toned or untuned. This can be applied simply to confer greater intensity in the negatives, or it can be used as a print when developed on paper or canvas. All other modes of intensification known can be applied in this case, but, among others, treatment with permanganate of potash, giving such a satisfactory result in carbon transparency, is recommended.

Now I proceed to show you the manipulation of the process in practice.

This sheet of paper bears a developed image with pyrogallol. One half of the image is fixed with hyposulphite of soda, while the other half is left unfixed; cemented with the squeegee to the surface of glass, it is immersed in tepid water; on this occasion all the rules that are good for the carbon process are literally applicable in this process; for instance, the water must not be too hot. The paper is peeled off, and you observe how the still soluble bromide is running down. Part of the image is purposely left unfixed; white bromide emulsion, when running under the action of warm water, enables you to watch the rapidity of the solution, and also the moment when the development is completed. Now it is complete, it cannot escape observation that the unfixed part is a great deal more intense than the fixed part. Evidently there is something more left on the image than pure metallic silver—something soluble in the hyposulphite; however, the lights are clear, and this something is not affected visibly by light, so that in many cases, when intensity is desired, fixing can be usefully omitted.

In describing the mode of working, and the advantages of the new process for negatives, I must mention that, to use paper in the camera, some alteration in the apparatus must be introduced. The ordinary slides, although excellent for glass plates, are not of the best form that can be desired for paper negatives. I have no doubt that in the old pre-collodion epoch of photography, the users of calotype paper knew also the best slides for it, and perhaps among an old, long-forgotten bundle of apparatus, a useful hint might be discovered for a practical form of the slide most suitable for sensitive paper. It was not my good fortune to come across such a valuable hint, and, therefore, I had to design one for myself. It is out of the question to put the paper between two glasses; glass had better be eliminated altogether. After many trials I have come to the conclusion that the roller-slide is the most convenient system. One I described here, and used by many in connection with my sensitive negative tissue for the last seven or eight years, need not require being described again.

A band of paper sufficient for many negatives can be successively presented for exposure in the camera by acting on the projecting knob of the roller. In my original roller-slide, an opening in the shutter, protected with orange glass, permitted the watching of the number printed on the boundary of every length of negative. With a very sensitive gelatine tissue, which I perfected some time ago, this opening was inadmissible, since the light passed through the glass and ruined every negative. I had then recourse to an electrical bell alarm, which sounded when each negative was completely rolled away from possible harm; this system, tried during my last travel in Russia, permitted me to expose over three hundred negatives with perfect success. Recently, however, I have constructed this model before you, in which the position of the paper is recorded in a much more simple manner, and one that cannot possibly get out of order. On the boundary of each length of tissue, answering to the size of the negative, a hole is perforated; a spring acting on a system of levers gives notice of the position of the paper by projecting a brass knob, which disappears instantly the hole is passed. A revolving shutter, instead of a sliding one, is another very useful innovation.

While considering that the roller slide is perfection for outdoor work, I must admit that it has certain disadvantages when it is used at home, as, for instance, the necessity for cutting out every negative for development; and then the joining the band again is troublesome. Under these circumstances I have constructed this slide, which will take a flat sheet of paper; it must be considered only as a rough model, but slides on this principle will also prove useful in the field, being very light and only one-eighth of an inch in thickness.

It now remains for me to give an outline of the application of my invention to other branches of photography. You observed, in the negative just developed, that the image has considerable relief, and that this relief is greater in proportion to the intensity of the image. This suggests its application to the Woodbury printing process. The emulsion for this purpose must be in a thick layer, and not so opaque as to enable the light to act deeper, and by these means produce a greater relief. The image need not be reversed, as is the case with the ordinary process. The same image in relief can be utilized for numerous photo-engraving processes, having this advantage over chromated gelatine, that it can be produced quickly, and even by artificial light. Grain, when necessary, can be produced by mixing suitable substances with emulsion.

Another important application of this invention is to the photo-ceramic or burnt in photographs on enamel porcelain or glass. Vitriifiable powder is mixed with the emulsion, which emulsion, in this case, is principally that giving only a very thin image when developed on the suitable enamel porcelain or glass surface, is fluxed and submitted to the action of heat in a suitable furnace. It is of the greatest importance, but it is also of considerable difficulty, to be able to eliminate the gelatine from the image before it is put into the furnace, because if this is left the whole is raised in large blisters, and in this condition cannot be burnt in. In this invention, however, when the emulsion gives only a faint image, the quantity of gelatine left is so small that it can be carbonized without the bad effect of blisters and cracks; this enables me to recommend the process.

* Read before the Photographic Society of Great Britain.

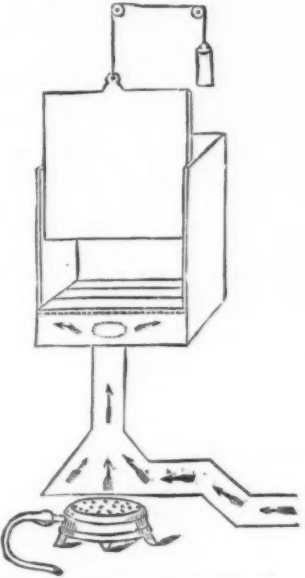
correspondence to the proportion to be obtained by these means, especially very fine. It is very intense, were formed the color of a substance at producing ordinary water developed portions it being it. By can be produced by the application of the sun, or it can be used. All in this in the color of the pro-

I pass for examination this glass plate on which the image in vitrifiable powder was produced; part of the plate was fired on the blow apparatus and is totally vitrified; the other part, which is much darker, not having been submitted to sufficient heat, shows how perfectly all the gelatine of the image is carbonized without being cracked or blistered; lastly, the lower corner shows the image not acted upon by heat.

My last remark is as to its application for phototype printing; having observed that the part exposed to light takes a greasy printing ink, a very easy application to this kind of printing can be imagined.

A DRYING CUPBOARD.

A HANDY drying cupboard, primarily intended for photographers, but also useful for other purposes, is described by A. Cowan. The box (see cut), of sheet-iron, may be of any form most convenient, but the more shallow it is the better. A very good proportion is 30 inches high, 30 inches wide, and 10 inches deep from back to front. The front is closed up at the lower part about 6 inches, and a sliding door running in grooves closes the upper part, all but about half an inch at the top, a balance weight over a pulley sup-

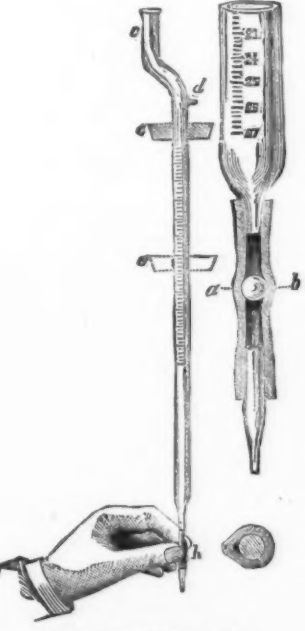


A DRYING CUPBOARD.

porting it in any position desired. This is much preferable to a door on hinges. The current of warm air enters at the bottom through a 3-inch circular opening, the iron stove-pipe arrangement being screwed on underneath. Above the opening at a little distance, is supported a thin shelf of wood about one inch smaller all round than the inside of the box, which acts as a diffuser, and stops the current of hot air from rushing up to one spot. Above this, at any convenient height, two bars are fixed to carry the feet of the drying rack.—The Brit. Journ. Photogr.

PELLET'S BURETTE.

The peculiar feature of this burette consists in a solid glass ball which serves the purposes of a faucet. Others have heretofore recommended the insertion, into the rubber joint at the bottom of the burette, of a short piece of solid glass rod of a slightly larger diameter than the caliber of



PELLET'S BURETTE.

the tube. A globe, however, is preferable, since it can be more easily retained in place, and, if desired, can be moved up or down with greater facility. It is only necessary to gently pinch the rubber tube at one side, to cause a flow of liquid, in a fine stream or in drops, from the burette. This improvement has been proposed by Mr. Pellet, of Paris.—Le Moniteur de la Photogr.

THE CANAL SYSTEM OF NEW YORK.*

WATER SUPPLY.

THE canal rises from tide at Albany to the Long Level between Lock 46 at Utica and 47 at Syracuse, which is 428.4 ft. above tide; here it drops to 400.7; then rises to 408.57, and drops to 392.07 at Clyde; 210 miles west, it commences a successful rise to Lake Erie at Buffalo, assumed at 571.68 above tide. These intermediate depressions are unfortunate in their effects on water supply, and oblige the heavy boats to face rising locks and westward currents. No attempt to correct them appears to have been made on the enlargement.

The canal is so located as to pop over the various streams which cross its line, and has 52 important aqueducts, with 4.6 miles of trunks and 284 culverts. The result is that its supply must be drawn from sources distant from these streams at the crossing points, and a large amount of the supply comes from a source like Lake Erie for the Western Division, and the Black River for the Middle, both being tributary to the St. Lawrence basin. To keep the original canal above freshet reach; to foster the use of mill-power, and to avoid the expensive damages for their appropriation on these inland streams, in connection with the limited supply required, are prominent reasons for this location as originally made; but they establish conditions unfavorable to enlargement.

The supply of the various levels is used by lockage, evaporation, filtration, leakage of structures, spillways (the latter often aggravated by wind pressure to a waste of several inches or a foot in depth), and also by a promiscuous use of the canal for mill-power, by small and large factories, from the Black Rock Mills to the Watervliet Arsenal.

Although the lock use is much increased by the necessity of indraught and flushing for unwieldy boats, the amount is not large as compared with other waste. On four locks, 53, 54, 56, 57, average lift, 7.69 ft., average contents, 12,300 ft., the use per lockage was 49,475 cu. ft. or 2.94 to 1. From Buffalo to Clyde, 142 miles, the lockage was 4,500,000 cu. ft., and other waste 48,353,200 cu. ft. per day, being 258.5 cu. ft. per mile per minute, for 125 lockages. The Montezuma level of 26 miles uses 17,500,000 cu. ft., or about 467 cu. ft. per mile per minute, the lock flow being 12,153 ft. per min. at each end, to supply this waste lost for eastward use. From Rochester to Clyde, the mean use is 3.32 ft. per mile per minute. The usual estimate of waste other than leakage is 200 ft. for the enlargement pressure of ordinary tightness, plus about 1,400 cu. ft. for weigh locks, 200 for aqueduct, waste weir and dry docks, each per minute.

Experiments on the old canal gave for evaporation 3 cu. ft. per min. per mile, filtration 63.5 cu. ft., waste, 9 cu. ft., total 75½, for these items: other experiments made the aggregate 85 cu. ft.

The number of boats passing per lockful is usually taken at 1.5 times; observations from July 6 to Sept. 30, 1847, showed 1.62 per cent.

The admirable manner in which the various and complicated problems in hydraulic engineering were determined by the original corps, reflects the highest credit on their judgment and skill. To supply the canal with water from Lake Erie for 142 miles to Clyde, reserving the Genesee River and other streams for mill power, required an arrangement of cross sections and grades, which was accomplished very successfully, and the enlargement repeated the problem on a much larger scale. In the last, from Black Rock to Lockport, the depth varies from 9 to 9½ feet, the surface width from 92 to 200 ft. and the grade from 0.0144 ft. to 0.268 ft. per mile. A comparison of the calculations of O. W. Childs, chief engineer in 1841, reported in 1847 with the actual dimensions detailed by Division Engineer W. H. Searles, in 1878, shows as follows:

	Estimated.	Actual.
Passing Lockport, ft. per min.	25-450	33-755
Surface width, ft.	96-46	96-45
Sectional area, sq. ft.	643-68	693-63
Passing Rochester, ft. per min.	13-290	12-175
Surface width, ft.	70	73-5
Sectional area, sq. ft.	432-00	500-38
Fall in 62½ miles, ft.	3-068	3-165

The original calculations were made from Eytelwein's formula,

$$\frac{\text{Area}}{\text{Perimeter}} \times \frac{\text{Fall}}{\text{Length}} = 0.000024265 \text{ (ft. per min.)} + 0.000114155 \text{ }^2, \text{ modified by Mr. Searles to Fall (feet per mile)} = P \frac{(c+6.534)^2}{6119.64}$$

On this Western Division the extraordinary use of the canal for mill power at Black Rock, and at Lockport, the latter taking about as much as the canal itself requires, produces in some cases a powerful current, exceeding one mile per hour, which is a great hindrance to westward boats. It is obvious that no use of the supply should be permitted, except the waste above the flow line, and for this injury to boat travel along the entire canal the State received only \$2,160 in 1879.

On this division, if restricted to lake supply, it is obvious that any material enlargement of prism and use would increase currents now objectionable, the draught from the Genesee being now restricted to about 1,200 cu. ft. per min.

The supply from Clyde to Syracuse is considered ample for the canal levels; but that of the Long Level, the summit of 55-65 miles, from lock 47 to 46 and 78-72 miles in all, to Little Falls, is not adequate at all times for the present prism, and would embarrass any material increase. The low water supply is from "Ilion" 800 cu. ft. per min., "Oriskany" 6,000, "Rome" 9,570, "Wood Creek" 125, "Oneida" 1,000, "Cowasselon" 200, "Chittenanga" 2,105, "Limestone" 1,821, "Butternut" 1,200; total 22,830 cu. ft. These streams have been carefully reservoired, but improvements may increase the amount to 26,429 cu. ft. The demand for 125 lockages, taken at 10,153 cu. ft. per min., added to the waste of the prism, at 222 cu. ft. per mile, 18,915 cu. ft., is 29,068 cu. ft. We find, therefore, that various annual reports complain of a defective supply, and advocate the use of Fish Creek, and enlarged reservoirs on the Black River. The state of this supply makes it clear that no ship canal could be fed on this level, and no material enlargement could be made, without a formidable outlay for water and its consequential damages.

From Little Falls to Albany for ordinary purposes the supply is ample.

DEPTH AND REMEDIES.

The experience of the Erie enlargement shows that in some respects it needs further improvement to develop its usefulness more completely. These will be noticed under the following heads.

Prism, width.—While various portions are beyond the standard width of 70 feet, and the water supply of the Western Division involves an occasional width of 204 feet at Lake Erie, to 73½ at Rochester, with a maximum depth from 9 to 9½ feet, there are occasional places 10 to 12 feet less than 70.

Depth.—It also appears that the standard depth of 7 feet for the Middle and Eastern Divisions does not exist for the standard bottom width of 56 feet, partly from occasional neglect in construction, and also from occasional low water, but chiefly from the wash of the sides, and into the canal. Boats of 6 ft. draught are liable to ground, and on a trial trip made by State Engineer Seymour in 1879, from Buffalo to Troy, the detention on this account, with 6 feet draught, was 8½ hours. On the long levels the winds are apt to make a deficiency at one end, at times of nine inches or a foot, with great waste at the other, the weirs and lock gates not being regulated to provide for this reduction; low water also occurs at times upon defective supply.

Ed Grass.—From July to the middle of September an abundant growth of ed grass obstructs water flow and navigation, requiring on the Western Division, at some points, an additional head of one quarter inch per mile to pass the supply, where the normal head varies from 0.816 inch to 0.8 per mile from Lockport east. The grass detaches and floats off in September, after fruiting; it is necessary to cut it at times; puddling the bottom would not prevent germination; iron oxides probably would, and if they could be cheaply used, might be of service in special districts; concrete flooring would also be effective on a firm foundation; but the remedies are expensive.

Curves.—While at times very expensive changes of line were made, resulting in a reduction of 11 miles in length, there are many curves, and occasionally those too abrupt for the passage of coupled boats; a case like this occurs near the Rochester aqueduct and others near the locks. For economical steam propulsion they need improvement, and all the curves are direct hinderances to the Belgian towing cables, their trains, and the boats they meet.

Low banks are common on the line, and interfere, at times, with full depth in the prism; they are washed by storm waves and steamboat waves, and should be brought up to 2½ feet above flow line on this account.

Bank Walls.—Portions of the canal have never been widened at the bottom from 52½ to 56 feet; on the Long Level 24 miles remain in this state; in the present general condition of the bottom, which keeps loaded boats near the center, the difference in angle of traction is not affected, but lack of depth and width, at times, seriously increases boat resistance, and interferes at present with the proper use of steam power.

Currents.—The canal levels are subject to powerful currents, chiefly flowing eastward, in the line of maximum load. From Lake Erie, for 153 miles, the flow varies from over 1 mile to 0.1 mile per hour; on the Syracuse level a westward current of 0.19 mile at times is met; on the long level another of 0.16; east of Utica, an eastward flow is 0.39 mile; east of lock 40, 0.49 mile; average to Troy 0.42 from lock 23; the mean eastward current is taken at 0.24 mile. This assists the loaded boats much of the way, but the ascent of 44 feet, by 5 locks, east of Syracuse, to the Long Level, and the resulting currents are serious objections to movement, and would have warranted very large expenditure to modify them; the delays at these locks is sometimes equal to the other 67. These currents are also due to a vicious use of the canal for mill power.

Side Walls.—A prominent cause of water waste is bank filtration, and a prominent cause of breaks, in addition to leaky culverts, is bank rupture caused by muskrats, roped filtration, storm wash, and otherwise. The difference in first cost between side walls laid in cement, or dry, is less than the cost of the mortar, because it requires less care in selection of stone and less time in laying. A wall laid dry for \$1.25 can be laid in cement for \$2.25 per yard, and one will protect the bank, where no care will enable the other to do it. The use of dry slope walls on the enlargement has involved ruptures, damages, delays, repairs, restriction of speed to prevent wash, and other hinderances, on which the excessive outlay for repairs furnishes but one comment.

The standard slope is 1½ to 1, for the lining, of 15 to 18 inch stone, backed with 8 inches of broken stone and gravel, with a paved front angle; tow-path width 14 and berm 10 feet; outside slopes two to one; with full 56 feet bottom the lining slope is 1 to 1. Neither 1½ nor 1 to 1 is a "slope of repose," and must, therefore, be artificially protected. The constant inflow through the face washes out the backing support and it cannot be kept in line; at 1½ to 1 boats must travel 8½ feet further from the tow-path than at ½ to 1, and this gain in traction is important—in favor of cement masonry. It is difficult to understand why engineers are so tenacious of dry wall faces in any hydraulic constructions, and especially on lines like the Long Level, where a defective water supply is a serious hinderance to increase of dimensions or depth, as to prevent movement.

Locks.—The enlargement locks are fine specimens of masonry, with graceful inlet and outlet curves and faced with cut stone. On the Erie they are uniform in width and length; on the Champlain vary from 99 by 143½ to 100 by 15 10-12 and 102½ by 183½, about half being 110 by 18. The Erie locks are now all double (since 1874), with 110 feet between quoins posts; a floor width of 17 ft. 4½ in.; a side batter of ¼ inch per foot, with a floor depth of 7 ft. 9 in. The side walls have 7 ft. 8½ in. base, with buttresses 9 feet wide by 2½—24 feet between centers, to support the middle walls, if such dimensions require it—the coping being 4 ft. wide. The highest lift is 15½ feet (No. 1 at Albany), the usual lifts being 10 feet and under. The foundations, flooring, miter-sills, and gates are of wood, an unfortunate plan as to walls and floors; and the excessive use of masonry is in singular contrast with perishable foundations.

I have always avoided the use of wood where masonry could be substituted. The theory that, submerged, it is imperishable, is not tenable; durability in special cases being the exception to a common law. All organic matter, diseased or separated from its source of life, is subject to algaoid or fungoid fermentation and decay; a process independent of air, heat, and light, promoted by moisture, and sure to occur whenever and wherever the genus exists.

The locks are fed and emptied entirely through the lock gates; for the ordinary paddles Heath's tumble gates are being substituted with advantage. A central culvert 5 feet wide and high, with an arch of 2½ feet radius, connects the upper and lower levels, with gates to regulate the flow.

* A paper presented to the Western Society of Engineers by Samuel McElroy, C.E., March 1, 1881.

The increased size of locks and boats, and the defective models of the latter, have materially increased the lockage time. In 1847, lock 26, 8 feet lift, passed 6,930 boats, an average of 281 per day, or 6-19 minutes each, proximately $8\frac{1}{2}$ down and $4\frac{1}{2}$ up. The time required to discharge an enlarged lock is 3 to 4 minutes, but the boat movement is slow. In 1877, with two horses, 9 boats at the Port Byron lock, 11 5-12 feet lift, averaged 21 32-60 minutes; with four horses, 11 boats, 16 37-60 minutes.—*Rept. 78, p. 103.* Lock 30, 10 1/2 feet lift, in 1867, passed 197 boats down on 17 minutes average, and 71 up with 9 minutes average; ordinary time is 19 down and 11 up, the return boats being light. The five ascending locks make the time longer, and practically restrict the entire eastward movement to their delivery.

The application of side ports and gates to shorten the time of filling and emptying, and the use of turbine power and wire rope to handle entering and outgoing boats, are simple and necessary improvements. The estimated cost of the latter, in 1879, was \$3,200 per double lock, or \$230,400 for the Erie Canal. A steamboat can also lock through much more rapidly from its available power. I see no reason why the lockage time, for loaded boats, may not be reduced to 12 minutes or less.

Capacity.—The original canal, with cargoes of 80 tons, capable of 52,000 lockages, or 26,000 one way, could pass 2,080,000 tons eastward per season of 210 days, and in 1847 did pass 21,980 boats east. The enlargement, at 19 minutes for one tier, can pass 15,750 cargoes of 30 tons, or 3,622,500 tons; in 1878, No. 26 passed 13,170 boats east. If reduced to 12 minutes lockage, the capacity of one lock will be 25,200 boats, or 5,795,000 tons at 30 each, but this cannot be done with the present models, which should be reduced to 200 tons load or less.

Boat Models.—On the theory that economy of transportation depends on the weight of cargo, boat models have been authorized by the Canal Board, without proper regard to resistance, speed, and handling, and have seriously vitiated the benefit of the outlay. They are built with vertical ends and sides, without proper entrance and outlet lines for the wave of displacement, and actually choke the locks, into which they must be drawn by a strong current of wasted water, and out of which they must be surged by flushing from the upper gates. Measurements made on the Western Division on four locks, from 4 7/8 to 10 feet lift, showed a use of 2-47 to 3-43 times the lock contents in passing these unwieldy hulls. A boat drawing 6 1/2 feet, with 17 1/2 feet width, has to pass through a lock 17 ft. 5 1/2 in. wide at the base of the boat, on the lower level, or 1 1/4 feet above the floor. This is not the most serious objection; where a naval architect gives the mould lines of a hull, about 50 per cent. of the submerged length, breadth and depth, canal boat builders are content with about 6 per cent. in standard cases, and a hull 95 by 17 1/2 by 6 ft. draught, has a displacement equivalent to a solid of 89-53 by 17-5 by 6 feet. Even the Wm. Baxter, built and certified as a prize propeller, has 89-33 per cent. of her solid form in displacement, with a "bottom perfectly flat, and sides, stem, and stern vertical." Her proportions match the professional indorsement of her performance, which cost the State \$35,000. The failures of steam propulsion are easily explained.

STEAM PROPULSION.

Through defective depth, models, and other causes, the speed and economy of other canals have not been realized on the Erie, and the efforts of the State to introduce steam were handicapped by improper conditions.

April 27, 1871, an act was passed offering a reward of \$50,000 for a steam canal boat, to carry 200 tons cargo, at three miles per hour average speed, of convenient form and action, to cost less for transportation than horse power, and appointing a commission to make the tests and award. In 1872, twelve steamboats were placed on the canal with stern wheels or screws of different plans; of these only three made the three round trips from Buffalo to New York required by the commission. The contestants having failed, in 1873, five boats were tested between Syracuse and Utica, but the commission declined to make any award. Resort was made to the Legislature, and in 1874, by special act, Wm. Baxter was to be paid \$35,000 for placing on the canal seven boats of the power and capacity of one of his, tested in 1873, able to "fulfill the requirements of the act of 1871," and D. P. Dobbins \$15,000 for furnishing three boats, equal to one tested by him, with the same proviso.

These boats did not show a careful regard for the principles of propulsion. The stern-wheeler Port Byron made a slip of 67-2 per cent.; Mr. Dobbins' boat, 66-3; two others, 51-6 and 54, an illustration in itself of gross defects; the Wm. Baxter tested in this group was credited with only 32-1, with a hull of 89-53 per cent. displacement, and a pair of screws working toward each other, behind such a model. In 1872 she made three trips from West Troy to Buffalo in 77 days, nearly 26 days each, with 102 1/4 tons up and 202 1/2 down, including lay days, etc. The inspecting engineer estimates a saving of 26 1/2 to 50 per cent. in cost of transportation by the Baxter system, taking railways at 0-23c. per ton per mile; horse boats, 0-53c.; and Baxter, 0-20c., the last estimate being about as accurate as the first. In 1874 this boat made eight round trips from New York to Buffalo; for 215 days' season, an average of about 27 days per trip, that of horse-boats being 30.

The "Belgian" plan of towing by a tug carrying a clip-drum which takes on a wire cable, stretched along the canal bottom, is new in partial use on the Western Division. The plan is to tow a train of five or more boats, charging each 20 cents per mile. On a trial trip of Nov. 17 and 18, 1879, five boats were then hauled at 2-774 miles per hour; 93 miles were made in 3 1/4 hours, about 30 H. P. being developed for 81 miles; part of the way a sixth boat was towed. Whatever the success of this plan may be for other channels, the Erie is too narrow and crooked for its use, and the recent report of the canal superintendent condemns it for defects, which experienced engineers would have anticipated. The tendency to haul the cable across the salient angles, brings the tug and train in contact with their walls, injures the masonry and banks, obstructs meeting boats, and delays movement. Some positive method of keeping the cable in mid-channel is needed, and with some expense could be applied. At 20c. per mile the inducement to boats rests in speed gained, and at 2 1/4 miles per hour with a strong eastward current this is not much improved; at 6 H. P. per boat equal to about nine horses, the economy is not demonstrated for the operators; and as the case stands, the system is much opposed by the boatmen.

The use of a steamer, coupled behind a consort, has been copied from other canals and promises to be a decided improvement, when it can be properly used, as to speed and cost. The best time made by the Emma and Consort in 1879, was twenty-one days per round trip to New York, 497 miles each way. On trial trip on the long level the speed

was about 2-2 miles per hour, coal, 92-4 lb.; slip, 42 per cent.; indicated H. P., 12; at 7-7 lb. coal per H. P. per hour the waste is large, good engines being run for three or less; the use of twelve powers is equal to about eighteen canal horses, for two boats, where eight would insure equal speed; and the loss of action and by reaction is shown by 43 per cent. slip of the screw, which must have a hull with moulded line, to lead solid water around it, and prevent reacting displacement waves behind it.

Locomotives.—A company has proposed to lay a track on each bank, and tow boats for 10 cents per mile, in trains of five boats, at about 3 1/2 miles per hour east and 4 1/2 west. The efficiency of this system is clear, but there is much opposition to granting a railway franchise on the canal. To this system, it is objected with reason, that the boats cannot be readily backed, though they are, with setting poles, as well off as horse boats, in this respect.

Commissioner A. Buckley, in 1872, experimented with a steam wagon, hauling two loaded boats six miles, from West Troy to Albany, in 1 1/2 hours; various experiments have demonstrated the feasibility of hauling trains of 20 or more boats in line. The Scotch and Swedish experience shows that the speed need not be limited to three miles, or five, per hour, and the economy of steam *versus* animal power is sufficiently proved to warrant the hope that proper engines in proper hulls may yet have on the Erie the proper depth and side walls to work in.

CANAL BUSINESS.

The annual statistics show the singular fact that, while the original canal was an immediate success, in its business and its income, so that the cost of construction for the enlargement itself was largely exceeded before 1862, the subsequent experience has not been in keeping with the annual increase of Western productions. 1847 appears to have marked in some respects the culmination of canal prosperity, and 1862 shows a business and income, from which after years recede, slightly in excess of 1879, in tonnage, and far beyond it in tolls and boat mileage. In 1879 the canal brought to New York only fifty-seven of the one hundred and sixty-three millions of bushels of grain delivered, and carried only 16 1/2 per cent. of the shipments from the West to the seaboard.

COMPARISON OF CANAL BUSINESS.

	1835.	1837.	1847.	1862.	1873.	1876.	1878.	1879.	1880.
Lockages west of Schenectady.....	10,985	21,055	43,957	34,977	24,960	16,661	26,340	.....	.....
Tonnage, total canals.....	1,171,296	2,869,810	5,598,785	6,334,782	4,172,129	5,171,320	5,362,383	6,462,290	.....
Tonnage, total Erie.....	667,151	1,661,578	3,204,277	3,602,525	2,418,422	3,608,634	.....	.....	.....
Barrels flour from Buffalo.....	126,815	1,903,351	451,814	13,616	2,139	2,805	.....	.....	.....
Barrels flour from Oswego.....	66,002	610,494	499,825	37,241	8,953	12,907	.....	.....	.....
Bushels wheat from Buffalo.....	450,350	5,816,362	27,751,786	24,569,088	12,577,233	25,833,866	.....	.....	.....
Bushels wheat from Oswego.....	10,025	713,831	7,408,513	1,775,393	729,666	807,700	.....	.....	.....
Freight boat mileage (total).....	5,556,950	11,733,250	13,021,950	9,480,900	5,823,200	8,450,551	8,226,947	10,401,904	.....
Tolls per ton, East, wheat.....	.....	.....	\$2.92	\$2.12	\$1.06	70-4c.	35-2c.	.....	.....
Collected, canals.....	\$556,279	\$1,292,623	\$3,333,347	\$4,792,535	\$2,976,718	\$1,167,226	\$913,765	\$901,471	\$1,183,332

The foregoing abstract of Erie Canal business illustrates its comparative culmination and decline.

A prominent cause of this result is found in active railway competition and discrimination; but these do not explain the entire reason. In its earlier days, the canal reduced the time of transit and the cost; in later days it has suffered from delays in movement and comparative increase in cost.

If we take the experience of 1879, as an index, the following comparison may be made.

The average freight on the lake from Chicago to Buffalo, for 917 miles, was \$1.11 per ton, or 0-161c. per ton-mile, for 4 1/2 to 5 days' run; the time by rail from Buffalo to New York is less than two days, and the charges \$3 per ton, or 0-672c. per ton-mile, a total of \$4.66. This was in September and October. On the canal the charges to New York were \$3.59, or 0-77c. per ton-mile—total, \$5.25, and the time of transit about 17 days from Chicago. Against the canal there is a difference in the busiest season of \$0.59 per ton, and 11 days' time. For the season of 1879, the average lake freight (wheat) was \$1.58 per ton, and canal charges \$2.28 1/2, or \$3.8 1/2 per ton for a trip time of about 17 days, while the "all rail" schedules, from March 24 to October 13, averaged \$4.40 for a run of about four days, the rates for part of the time being \$3, and the schedule rates above the actual charges. In this State the canal is useful in fixing a rate for summer freights, and in transporting a fraction of the shipments; but it ceases to be a formidable competitor, and takes what the railways cannot conveniently carry.

Tolls.—The policy of the State, influenced by local influences, and the depression of canal business, has been to reduce the tolls from time to time. In 1876 the free-list was adopted for some classes of freight, and the tolls practically reduced to about the cost of superintendence and repairs; so that the State abandons the income from her investments. On grain the present toll is one mill per ton-mile, and it is proposed to abandon the tolls on westward freights.

Transportation Cost.—Since the value of the canal as a competitor depends on the time and cost of movement, in view of what has been said of its dimensions, facilities, defects, and remedies, these items of cost are important.

As to the canal proper from Buffalo to Albany, the original and enlargement, may be computed on the basis of relative speed, tonnage, and expenses, in the following estimate, assuming the old boats at 80 tons cargo East and 32 West, and the enlarged 230 East and 92 West, which is much in excess of general results. Prices were much lower in former days, but the maintenance, horse-power, and harbor expenses will be taken on a common basis.

The comparative items will be—Original canal: Boat, \$1,800; 4 horses and harness, \$550; total, \$2,350; annual expense—Interest at 6 per cent., \$141; depreciation and repairs of boat 12 per cent., \$216; horses, \$63; insurance, \$10; total, \$430; 7 1/2 months' crew—Captain, \$40; steersman, \$12; 2 drivers \$28; cook, \$10; food for 5, \$60; total, \$975; horse keep to \$90 per month, \$450; cargo insurance, \$144; wharfage, \$48; discharge 80 tons, load 32, at 20 1/2 c. for 12

trips, \$273; commissions, \$156; total, \$621; amount for 12 trips of 1,344 tons, \$2,476—\$1.84 per ton, 0-507 per ton-mile.

Enlargement—Boat, \$3,250; 4 horses, \$500; harness, \$50; total, \$3,800. Annual expense, 6 per cent. interest, \$228; boat depreciation, 12 per cent., \$390; horses, \$100; insurance, \$20; total, \$738; 7 1/2 months' crew—Captain, \$50; steersman, \$15; 2 drivers, \$10; cook, \$12; food for 5, \$60; total, \$1,178; 4 horses, \$450; cargo insurance, \$35, by 9 trips, \$315; wharfage, \$63; discharge \$280, load, 92, at 20 1/2 c., 9 trips, \$589; commissions, \$270; total, \$1,237. Amount for 9 trips of 2,898 tons, \$3,603—\$1.243 per ton, 0-35c. per ton-mile.

COMPARATIVE TABLE.

	ORIGINAL.			ENLARGEMENT.		
	Amt.	Per ton.	Per ton-mile.	Amt.	Per ton.	Per ton-mile.
Capital.....	\$2,350	.....	.....	\$3,800	.....	.....
Maintenance.....	430	\$0-32	0-188c.	738	\$0-254	0-079c.
Crew.....	955	.....	.....	1,178	.....	.....
Horse-power.....	450	1-06	0-292c.	450	0-561	0-156c.
Harbor, etc.....	621	0-46	0-127c.	1,237	0-427	0-121c.
Total.....	\$2,476	\$1-84	0-507c.	\$3,603	\$1-243	0-35c.

Adding a proper transportation charge, in comparison, the tolls at 1 mill per ton-mile, as covering expenses of supervision, etc., the enlargement total is 0-45c. and the old canal 0-607c. per ton-mile, its practical reduction being 25 86-100 per cent.

The earlier reports, in some cases, give the original cost at less than three mills per ton-mile, but are obviously in error. In 1851-2-3, the cost of horse-power and wages in moving 120,225 tons was \$1.67 per ton, or 0-46c. per ton-miles for these items. The estimate of 1850 for towing, wages, canal repairs, and boat depreciation was 0-565c. Calculating on the difference in cargoes, the enlargement promised to reduce this one-half. Estimating on gun-boat locks, in 1864, the relative cost was made: Old boats, 0-414c.

enlargement, 0-216c.; gun-boat, 0-104c." (prism 70 by 8 feet). Experience shows the fallacy of such estimates.

Through Movement.—For a long time the through produce has been carried to New York by making up trains of 75 to 100 boats at Albany and towing them by powerful steam-boats, taking about 60 hours in passage. The charge usually estimated is \$25 to \$35 per round trip, including harbor towage to discharging and loading points. Under this system the number of round trips is reduced to 7, and the tonnage to 2,254—an overbasis. The cost of crew is reduced for about 70 days on the river from \$5 to \$2.50 per day, or \$1.75; the insurance, \$70; wharfage, \$14; commissions, \$90; discharge and loading, \$131; total, \$450; being, less \$175 towage \$-75, or \$3.325, or \$1,476 per ton for 497 miles, or 0-3c. per ton-mile; or, with tolls, 0-4c. This makes the actual cost from Buffalo about \$2 per ton, but practically the cost by lake and canal from Chicago is about \$2.92 per ton.

Buffalo Charges.—Much hinderance to canal traffic has been created by the excessive charges for transshipment and loading at this port.

The "pool" of elevators which is said to be under railway control, charges one cent per bushel for weighing and transferring grain, seven-eighths to the owner and one-eighth to the vessel; there is also a charge of \$3.50 per 1,000 bushels for shoveling and trimming, and another for blowing and screening; these rates are at least double what they should be, and amount to a tax of not less than \$0.363 per ton, including the deliveries in the hands of commission men, combined so as to control the boatmen, who must be paid about \$25 for each load, and a percentage as the insurance of cargo required. So far as can be judged from the testimony on this point, the policy of the State and city of New York is to make the Oswego Canal, in all respects, an adequate rival of the main line, as a check on these stringent reductions of canal business. The manner in which rates are raised when the deliveries increase also operates against canal shipments and is a radical mistake.

Proposed Improvements.—Various improvements have been discussed with more or less care, since 1862, to improve the canal business. The following are among the most important plans:

Gunboat Locks.—In 1863, under State Engineer W. B. Taylor and Charles B. Stuart, C.E., acting on the part of the government, an elaborate estimate, with plans, was prepared, for enlarging the locks to 225 by 26 feet by 7, with 8 feet depth of prism. The cost was:

Locks.....	\$8,328,813
Removing wall benches.....	1,784,185
Deepening one foot.....	1,789,900
Oswego to Albany.....	\$11,902,888
Demand for long level 35,463 feet per min. Supply assumed 28,648.	10,350,088

amount for 12
0.507 per ton
5500; harness,
cent. interest,
horses, \$100;
crew—Captain,
12; food for 8,
\$35; by 80, load, 92,
total, \$1,337.
\$1,242 per ton.

Per ton. Per
ton-mile.
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0-581 0 1500.
0-427 0-1210.
1-242 \$0-35c.

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Supply

In 1875, a report was made by United States engineers (Major Wilson and others) for substantially the same plan; the estimate being reduced to \$8,173,596.

Another estimate was made for a ship canal from Oswego to Albany, 200.45 miles, prism 140 feet surface, 130 bottom, 10 feet depth; locks 183 by 29 by 9 feet; boats about 650 tons; estimated cost \$25,213,857. The defective water supply, 67 locks, 608.76 feet lockage, and excessive cost are fatal to this plan; as to the other, in a case where the engineers were controlled by express terms of legislation, as to lock size, it is enough to say that no gunboats, or canal boats, really intended for practical work, would be built to suit locks 225 by 26 by 7 feet; the proportions of the present boats are bad enough.

The report of State Engineer H. Seymour, Jr., for 1880, recommends dredging out the canal one foot, so as to make eight feet depth, the cost being estimated at 1,000,000 yards at 12 cents, or \$120,000; also for raising the flow line one foot, estimated cost \$1,000,000. Former reports advise the use of turbine power for the locks, to facilitate the handling of boats at an estimated cost of \$230,400 for 73 locks.

Whatever the cost may be the advantage of giving the present hulls, properly improved in model, as time permits, greater water way between the structures (which cannot be depressed), with machinery to facilitate lockage, is as obvious as that of water-tight banks and straightened lines to facilitate steam towage. These are indispensable to the reduction of transportation cost. With 8 feet depth, in the main, and 6 feet draught, nothing is practically gained by attempting to raise the flow line. It involves serious expenditures along the whole line, aggravated water waste, and currents, on the theory that boats still more unwieldy than the present ones can be used to carry fifty additional tons. The increase of speed is the most direct line of gain for the present limited water supply.

Beyond a certain range of improvement, which has been indicated, it is useless to attempt enlargements. Located through a densely populated region, above the water courses, crossed by 540 bridges, there is a direct limit to the business of the Erie Canal, and when New York City wakes up to the rivalry of the Canadian system, the Welland scale of movement must be met by the use of the original transportation valley of the State, in which the Hudson flows. This route, and this alone, will bring transportation to nearly lake and ocean scale of vessels and cost.

What the Erie and Oswego Canals then need is:

1. Proper power at the locks for boats.
2. The abolition of supply for mill power.
3. Legal restriction of harbor charges.
4. Improved prism lines and section.
5. Eight feet depth between structures.
6. Solid masonry side walls $3\frac{1}{2}$ feet above flow.
7. Improved boat models.
8. Practical and intelligent steam propulsion.
9. Absolute control by the State Engineer of construction and maintenance.

[Continued from SUPPLEMENT 291, page 4644.]

ON HARVESTING MACHINERY.*

By Mr. E. SAMUELSON, Banbury.

Side-delivery Reaper.—In this class a quadrantal platform is fixed to the back of the cutter-bar, and suitably supported off the ground by stays; on the main body of the machine is an upright shaft, and to this shaft are fastened four or more rakes. These are caused to revolve like the sails of a windmill, and, in so doing, gather the standing corn to the knife and then rake it off the platform when cut, throwing it behind the main traveling wheel, and thus leaving a clear track for the horses on the following ground. Except where the crop is desired to be left in a swath, as in the case of barley, it is usual to collect it in sufficient quantities to form a sheaf. The simplest method of doing this is to substitute for some of the rakes what are termed "gatherers," which only gather the standing crop to the knife, and then pass clear over the grain lying on the platform, which thus remains there until the next rake sweeps the sheaf off.

The methods by which these rakes are caused to travel round in the necessary path are various. One plan is to hinge the rakes to the upright shaft, and to guide them from another fixed point by short rods. Another is to incline the rake shaft towards the platform. In both these plans the platform must be curved to suit the path of the rake, and this is objectionable, as in time the platforms are liable to lose their shape; and further, in the latter plan, the rakes do not enter and leave the crop at the proper angle, namely, at right angles to the ground.

A third plan is to substitute a chain for a rod, to make the platform flat, and to guide the rake over it by means of a cam path; but the more usual plan is to use a cam path alone, of suitable shape. A rake may be turned into a gatherer, either by lifting up the rake-head bodily, and fixing it upon the rake arm, which travels round in the same path as before, or else by causing the rake-arm to take a low path in front of the grain, and a second or higher cam path whilst passing over the platform. The disadvantage of the first method is that the gatherer has not the low path given in the second, and so is not able to cope efficiently with a laid crop. The rakes may be set as gatherers before starting to work, when the machine is at rest; but it is sometimes desirable to suspend the action of one or more of the rakes whilst at work. It is then necessary that the driver should be able, from his seat, and while the machine is in motion, to shunt the rake on to the higher path; and this is done by means of a movable portion of the cam or switch. The draught of a reaper is taken from the main frame, and a side-draught arrangement is sometimes used. The tilting of the fingers is always provided for in side-delivery reapers. The usual width of cut is from 5 feet to 5 feet 6 inches, and the average weight of the machine is from 10 to 11 cwt. for side delivery, and from 5 to 6 cwt. for manual reapers.

In designing a reaper, care should be taken to keep the line of cut in the center line of the main axle, in order to follow the unevenness of the ground, and also to avoid cutting into the solid soil when turning the corners. In some cases this line cannot be maintained, and then this latter fault is overcome by making the off-side wheel to swivel.

In concluding we may notice a class of machine which is used as a combined mower and side-delivery reaper. This is a two wheeled machine, and has the cutter-bar placed behind the main wheels, so that the rakes throw the sheaf clear of the wheels. This combined machine is likely to come into use only where the crops are not very heavy or

much laid; but it is a useful machine where the crops on a farm consist chiefly of grass, and the expense of a separate self-raking reaper would otherwise have to be incurred for a small area of grain.

Automatic sheaf-binder.—These have been for many years past a fruitful subject of invention, but it may safely be said that at the present time there is not a binder that can cope successfully with a heavy English crop, unless it stands fairly upright. On the other hand we must give due credit to the Americans, who have produced machines capable of dealing with the short dry crops of their own country, and also to the English makers who have produced machines applicable to such crops as are grown in the colonies, and in the south of Europe.

The material used for binding the sheaves is either wire or string. A strong prejudice is shown by farmers against the use of wire, on account of its finding its way, in the hands of a careless laborer, into the threshing machine, thence into the chaff, and occasionally between the mill-stones. But this difficulty can be overcome if a pair of pliers are used, which cut and hold the wire at the same time. The advantage of using wire, from a manufacturer's point of view, is that it presents far less difficulty to deal with, as a twist only is required in order to fasten the two ends together, while with a string a knot is necessary, and the tension and cutting of the knot require more attention. The crop may either be cut and bound in sheaves in one operation upon the same machine, or else it may be cut by an ordinary side-delivery reaper, and then followed by a binder, which picks up the loose sheaf or swath from the ground, and binds it. As this latter form of machine is not in use in this country, and only to a very slight extent in America, the writer will confine his attention to the first class.

In the usual design of a binder, a reel is substituted for the rakes of a reaper, and the cut crop falls upon a traveling platform, from which the grain is elevated over the main traveling wheel by means of endless aprons, and falls on to a table upon the other side. Under or above this table is placed the knotting or twisting mechanism. The wire or string is placed round the sheaf, when sufficient has been collected, by a radiating or rotating arm, carrying a needle; and when the knot or twist has been made, the string or wire is cut, and the sheaf is either kicked, or allowed to fall, off the binding platform on to the ground. The elevating aprons are generally made of canvas in pairs, and receive the grain from an endless canvas which travels over the platform; in other cases, instead of canvas aprons, endless bands, or chains provided with small teeth, are used.

The framework of these machines is usually built of timber, for the sake of combining lightness with rigidity; the off-side shoe is also of wood, with a separator of the same material. A better separation of the crop is made with this form of divider than with dividing irons, when a reel and not a rake is used, and when the grain has to be carried away from the off-side to the binding table.

The reel is driven by a chain gearing from the main axle, and is capable of being raised and lowered, with respect to the cutter-bar, by suitable tilting gear, worked by a lever within reach of the driver. The fingers are also tipped, and the beam raised and lowered, as before. The beam in all machines of American manufacture is a wooden one, the knife serrated, and the sections of a more obtuse angle than in the ordinary English machines. These machines are cumbersome, weighing about 15 cwt., and, as they measure about 12 ft. 6 in. in width, are incapable of passing straight through an ordinary English gateway. They must therefore be brought in sideways upon wheels provided for that purpose, or the beam must be hinged and capable of being turned up.

Another and more simple plan than that of elevating the cut grain over the wheel, is to keep it upon the level of the platform on which it falls when first cut, to bind on this level, and then to drop it on to the ground. In this form of machine the main wheel must be outside of the binding apparatus; the whole width of the machine is not increased thereby, but rather diminished. The weight of this machine is 12½ cwt., and the width 13 ft. This form of machine has been in practical work in America, and has also been worked successfully in this country during the past harvest, in heavy and occasionally even tangled crops.

Wire binding Mechanism.—In most cases the necessary twist is given by means of a small pinion, between the teeth of which the wire is brought, and the pinion then caused to revolve by putting it into gear with a rack or spur wheel. After having made three or four revolutions, the ends are sheared, and the bound sheaves set free, the loose end of the wire being still retained by means of a pair of jaws or nippers. The other end of the wire is brought into pinion again, after having been passed round the next sheaf by the arm or needle. This needle-arm in one design carries the twisting pinion itself, and, in the "Wood" machine, this needle makes a complete revolution, and, in passing under the binding table, comes into gear with a rack, which gives the necessary twist to the ends of the wire.

Another plan is to give the needle-arm a radial oscillating movement. This is done by suspending the needle above the binding table, on an oscillating bracket, and guiding the needle in the necessary path by means of a slotted cam link; the needle-arm then simply gathers sufficient to make a sheaf, passes one end of the wire under it to the twisting device, and, after the twist has been formed, rises up above the table, along its previous path, ready for another sheaf.

Again, instead of causing the needle to oscillate or radiate as described above, the bracket which carries it is sometimes caused to travel from the front or outside edge of the binding table to the back. The function of the needle-arm is thus to gather sufficient of the loose grain to form a sheaf, and separate it, while being bound, from that which is still falling in a continuous stream behind it; to bring the end of the wire or string to the twisting or knotting device, and to compress the sheaf whilst being bound, in order to give the necessary degree of tightness to the band. The compression is sometimes put upon the sheaf by separate compressing arms.

In Wood's machine the sheaf when bound is kicked off by a kicker arm, whilst in the case of the McCormick and other machines the sheaf remains upon the binding table, and is pushed off by the succeeding sheaf.

Another successful plan for forming the twist is by means of two pinions working face to face. These have the same number of teeth, namely ten, but gear into two small spur wheels, having respectively forty-eight and forty-nine teeth; which are caused to revolve simultaneously by a wheel lying underneath them coming into gear with a rack. Thus, as the pinions revolve, the one gains upon the other, and after having made four revolutions, the teeth of one lie over the spaces in the other, and by this action shear the ends of the wire. In this machine two reels of wire are employed, the wire forming a continuous band from one to the other, and

the jaws or nippers for holding one end of the wire are dispensed with. Instead of having one twist, two are made at the same time, one above and below the double pinion.

A still more simple form than any of those yet described is a revolving needle which brings the wire round the sheaf to a small twisting hook, which takes hold of the two ends of the wire, and fastens them together in the usual way; a pair of shear-knives are then brought into operation by the crank, and the sheaf is kicked off gently on to the ground by the kickers, one end of the wire remaining looped on to the hook ready for the next sheaf.

String-binding Mechanism.—In one of Messrs. Wood's string binders the knoter is placed above the binding table, while the needle arm rises up from below. The grain falls over the traveling wheel, after having been elevated in the usual manner, on to the binding table, and is brought under the string by a revolving packer against a compressor arm. As soon as sufficient has been collected to form a sheaf, the pressure upon the arm releases a spring, which, in its turn, causes the needle arm to rise up and pass round the sheaf, the packer in the meantime discontinuing to revolve. The needle arm brings one end of the string over the knoter, the other end being already there, retained by the jaws or nippers, while the loop contains the sheaf. The knotting hooks are then caused to rotate; but the upper hook advances for a short distance before the lower one commences to move, thus opening or separating the two hooks from each other.

After the hooks have made a quarter revolution, a spur is brought over the two ends of the string, and as the rotation continues, the string slips over the hub of the lower hook and comes into the necessary position.

When the hooks have reached this position they cease to rotate forward, and commence to revolve in the opposite direction. In so doing, the upper hook passes first over the two ends of the string, and closes into the recess upon the lower hook, thus grasping the ends of the string and holding them fast; then as the hooks continue to rotate backwards, a spring-catch or hook draws the loop over.

During the formation of this part of the loop, the jaws or nippers release the end of the string and take hold of the other end, which passes through the needle, at the same time cutting it; the two ends of the band which are round the sheaf are now loose; and the hooks continuing to revolve, the knot is completed by means of the catch, the weight of the sheaf drawing the loop tight.

The compressor arm now rises up, and the bound sheaf is kicked off the table by a kicker, on to the ground, the needle at the same time receding under the table. The compressor arm then returns to the former position, and the packer commences to form another sheaf.

This method insures the sheaves being of uniform size; and this size can be regulated in the first instance by the amount of tension put upon the spring catch, which is actuated by the compressor arm.

Another and more simple method is sometimes employed for forming the knot in a string binder. It consists of a hollow knotting shaft, having a hook or jaw at one end; inside this shaft is a sliding shaft, which also has a hook or jaw. The spindle has an independent longitudinal movement given in it, but rotates with the main shaft. These movements are given to the shafts by suitable gearing. The knot is formed as follows: One end of the string is held in a pair of jaws or nippers, and then passed over the shaft. The corn falls upon the string, and as soon as a sheaf is collected, the other end of the string is brought round the sheaf and laid across the shaft. The knoter shaft is then drawn back, and makes a revolution; and in so doing it brings the end of the string between the open jaws. One jaw then closes upon the string and holds the ends fast; the string is cut, and the loop lifted over the hook by a trigger; thus forming the knot, which is drawn tight by the weight of the sheaf. The hollow shaft having now come back to its first position, and the jaws opening at the same time, the sheaf falls to the ground.

The difficulties to be contended with in automatic binders are numerous. The proper separation of the sheaf from the continuous flow of corn, and the getting rid of the sheaf when bound, require much careful consideration; and further, the tension and cutting of the binding material require great nicety of adjustment. The binding mechanism, whether for wire or string, is generally carried upon a sliding shaft or upon ways, so that the band may be placed near the middle of the sheaf, whatever length the straw may be.

Although, owing to want of time, the writer has only described a few of the methods of making the twist or knot, yet he does not wish to imply that other devices are void of merit or interest; but those described are, he believes, those chiefly used in this country and on the Continent, and he has therefore selected them as being the most suitable to the present occasion.

In conclusion he wishes to express his best thanks to the Walter A. Wood Mowing and Reaping Machine Co., Hoosick Falls, N. Y., for their kind assistance in lending models of their wire and string binding devices, etc., and also to Mr. A. C. Bamlett for the use of those of his Mower and Manual Reaper.

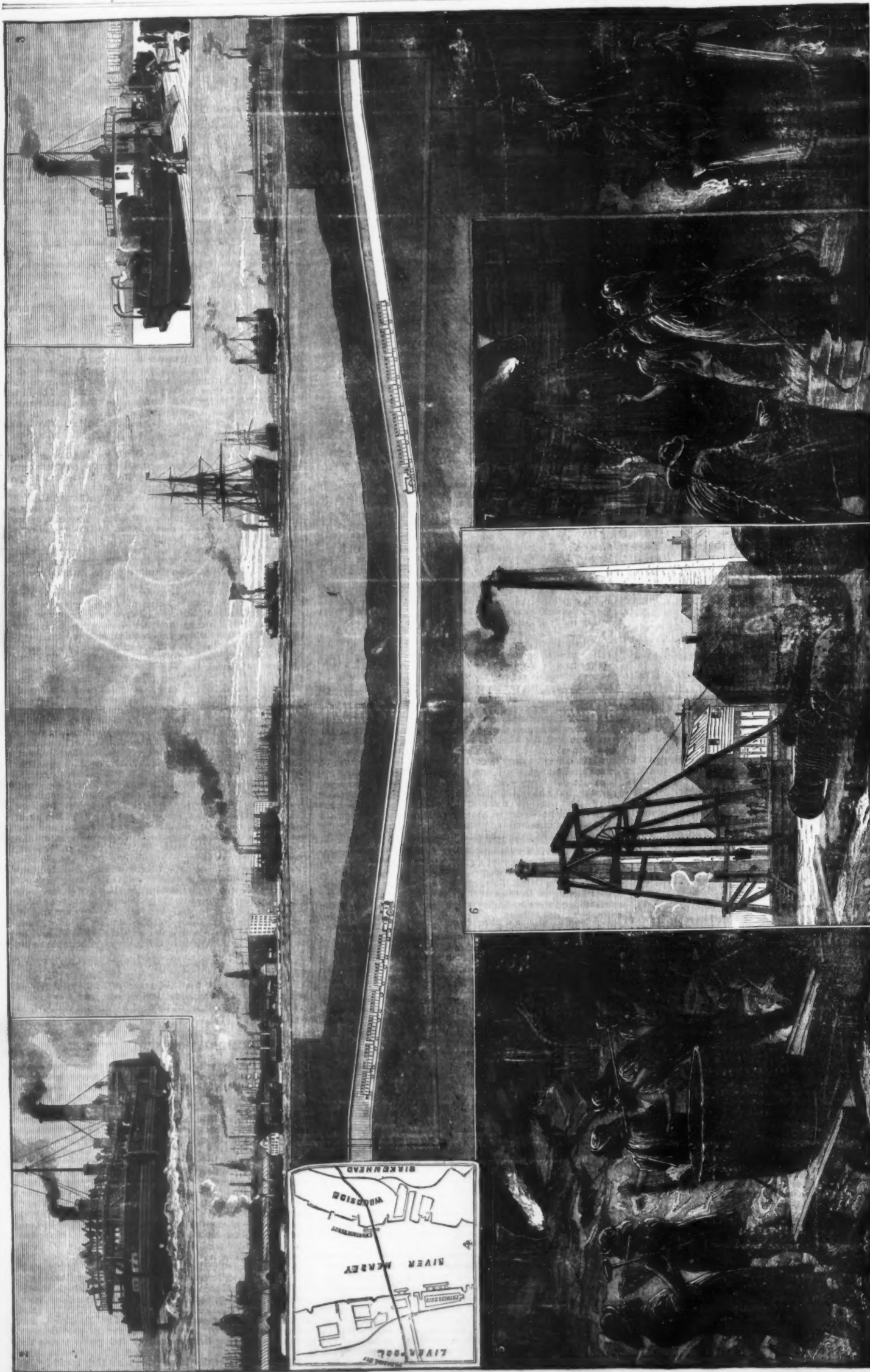
THE MERSEY RAILWAY TUNNEL.

THE illustrations which we present on another page show the design and preliminary constructive operations of a remarkable engineering work, intended shortly to join the great commercial city of Liverpool and South-West Lancashire with the opposite shore of the Mersey estuary, the town and docks of Birkenhead, and the Chester and Birkenhead Railway, giving access to all parts of Cheshire and North Wales, as well as to the Great Western Railway system.

The Mersey, where it flows between Liverpool and Birkenhead, forms a noble river harbor, three-quarters of a mile wide, affording ample accommodation to the great Atlantic mail steam-ships of the Cunard Company, the White Star, and other lines; but its shores on both sides, north and south, are indented with a series of docks, far surpassing, as a whole, those of any other port in the world. The Birkenhead docks alone have cost about six millions sterling; but those on the Liverpool side, which extend a total length of nearly seven miles, have cost probably twice that sum. The docks of Liverpool and of Birkenhead are now jointly managed by a powerful trust corporation, the Mersey Harbor and Docks Board; and these magnificent basins, with their vast piles of warehouses, constitute a depot for maritime trade that is nowhere equaled. The population of Liverpool and its suburbs now amounts to nearly 700,000, and it has become a matter of urgent importance to provide easy means of conveying both passengers and goods across the river.

The local authorities have done what they could by the

*Paper read at a meeting of the Institution of Mechanical Engineers.



4. Map showing Position of Tunnel.
8. Going down in the Bucket.

3. Ferry for Vehicles (present means of crossing).
7. Working at the Bottom of Shaft, showing Entrance to Heading.

2. Passing of Ferry (present means of crossing).
6. View of Birkenhead Works, showing Headgear, Engine-house, &c.

1. The Mersey, showing Section of Tunnel, Driftway, and Shafts.
5. Working at the Face of Heading.

THE MERSEY RAILWAY TUNNEL: PLAN AND SECTION, AND WORKS IN PROGRESS.

erection of landing-stages, at Prince's Dock and St. George's Dock, on the Liverpool side, and at Woodside, Birkenhead; and by instituting a service, between these points, of large and commodious steam ferry-boats, one class of them for passenger traffic, the others for vehicles of all descriptions. These ferry-boats, which are shown in two of our illustrations, run at intervals of a few minutes during the day, and less frequently during the night; but, well arranged and well conducted as they are, must necessarily be liable to delays and interruptions, especially in winter and rough weather. Another serious inconvenience and cause of loss is that the conveyance of merchandise across the river, by means of barges, involves great waste of time, heavy expense, and often serious risks.

Several proposals have from time to time been made for bridging over or tunneling under the river; and in the year 1868 the Mersey Railway Company was incorporated by Act of Parliament for this latter purpose. Mr. Robertson Gladstone and Mr. Harold Littledale being among its first directors.

After many delays and difficulties this enterprise, which is of really national importance, assumed a practical shape in the autumn of 1879; and early in 1880 the works were commenced by the sinking of shafts of large diameter at Woodside, Birkenhead, and St. George's Dock, Liverpool. Carried through the solid sandstone rock to a depth of 180 feet, these shafts are intended to drain the tunnel, which will, for a distance of 1,300 yards pass under the bed of the river. Powerful pumps, with engines and boilers of the most improved design, are fixed in these shafts, and are capable of delivering from five to six thousand gallons per minute on each side of the river. From the bottom of the shafts, trial headings have been driven to prove the rock, which has been found to be solid sandstone, sound enough for building purposes. In no place will there be less than 25 ft. of this rock between the crown of the tunnel and the bed of the river.

In our illustrations we have shown the pumping arrangements at one of the shafts; a number of workmen descending the shaft in the bucket; and the miners at work with drill and dynamite in the headings. These will be pushed forward with all speed from both sides until they meet under the river.

Referring to the map or plan, and to the sectional views of the proposed railway tunnel, with the driftway beneath, from one shaft to the other, the reader will comprehend the nature of the works that are now in progress. Mr. John Waddell, of Edinburgh, is the contractor, and the company's engineers are Mr. James Brunlees and Mr. Charles Douglas Fox. The extreme depth of water in the river overhead at high tide is 90 ft., and about 70 ft. at low tide. The average thickness of solid rock between the bed of the river and the crown of the tunnel roof will be 30 ft., and nowhere less than 25 ft. The width of the river here is nearly 1,800 yards. The shape of the tunnel will be oval, 21 ft. high from the formation level, and 26 ft. wide, these dimensions being fully sufficient for a double line of railway. It will be completely lined, so as to be thoroughly waterproof. The length of the Mersey Railway, from Church street, in Liverpool, to Tranmere and its junction with the Birkenhead and Chester Railway, will be two miles and a half, two miles of it being through tunnel; and it is intended to employ smokeless locomotive engines for the traffic. The works of construction, according to estimate, may be completed at a cost within the authorized capital of the company, which is £866,000, and August, 1883, is the expected date of their completion.

There are further designs of extension lines through Liverpool, communicating with the London and North-Western and the Lancashire and Yorkshire Railways, and with the southern docks; there would then be a central station in Dale street. On the Birkenhead side there will be a station close to Hamilton square, for the convenience of residents in that neighborhood, who will be enabled to pass in five minutes to their places of business in Liverpool. Those living at New Brighton and other seaside places of the Cheshire coast will likewise find the Mersey Railway a great daily accommodation.

A project for the construction of a subway between Birkenhead and Liverpool, for ordinary road traffic, has lately been entertained, originating with a committee formed in February of last year, and an Act of Parliament was obtained for the purpose. But at a meeting on the 5th ult. of the Mersey Harbor and Docks Board, when the whole subject was fully debated, it was resolved "that, considering the progress made by the Mersey Railway Company with their preliminary works, it is undesirable that the board should at present enter into any engagement with regard to the construction of a subway."—*Illustrated London News*.

THE ELECTRICAL RAILWAY OF GROSS-LICHTERFELDE, NEAR BERLIN.

The first time that Messrs. Siemens and Halske brought their electrical railway to the attention of the public was on the occasion of the Berlin Exhibition, in 1879, when it was looked upon simply as a beautiful experiment in electricity and an object of scientific curiosity. Since that period, however, this eminent firm have been able to render it practical. After operating their electrical railway at several more recent exhibitions, they have at length just finished the construction of a new electrical line—that of Lichterfelde, which runs from the railway station at Anhalt to the Institute of Cadets, a distance of one and a half miles. The rails, which are of steel, as in other roads, are 8-28 ft. apart, and fixed to wooden chairs. At about 1,000 feet from the station there has been installed in the machinery building of the hydraulic works a dynamo-electric machine which is rotated with great speed by means of a steam engine (Fig. 1). The electric current produced is directed into the rails by means of underground wires. It circulates in the wheels of the car and reaches another dynamo-electric machine, which, being thereby made to revolve, puts in motion the car wheels. The car exactly resembles those used in ordinary tramways. On the day of the inauguration of the road it carried, in addition to the conductor, twenty persons, twelve of whom were seated, while the other twelve stood up. The electrical machine is placed between the wheels of the wagon beneath the floor, so that it is nearly invisible, and attracts no attention. It works perfectly noiselessly (Fig. 2).

As we have before said, the current produced by the stationary machine is led by the rails to the circumference of the wheels. The latter are insulated from the axles, and are connected with the dynamo-electric machine under the car by means of contact rings, which also are insulated and arranged around the axle. Against each of these rings rests a certain number of collecting springs, which, during the revolution of the wheels, establish a continuous metallic com-

munication between the machine and the rails, the latter, as before stated, receiving the dynamo electric current through the intermediation of underground wires.

The passage and interruption of the electric current are regulated by means of a commutator which is under control of the conductor. The brake and the signal bell are arranged so that a single person is sufficient to run the car and collect the tickets. The car is symmetrical in shape, and can run in either direction without being turned around. The German authorities require that the mean speed of the train shall be 9 miles per hour and never exceed 12; but it would be easy to attain a much greater velocity.

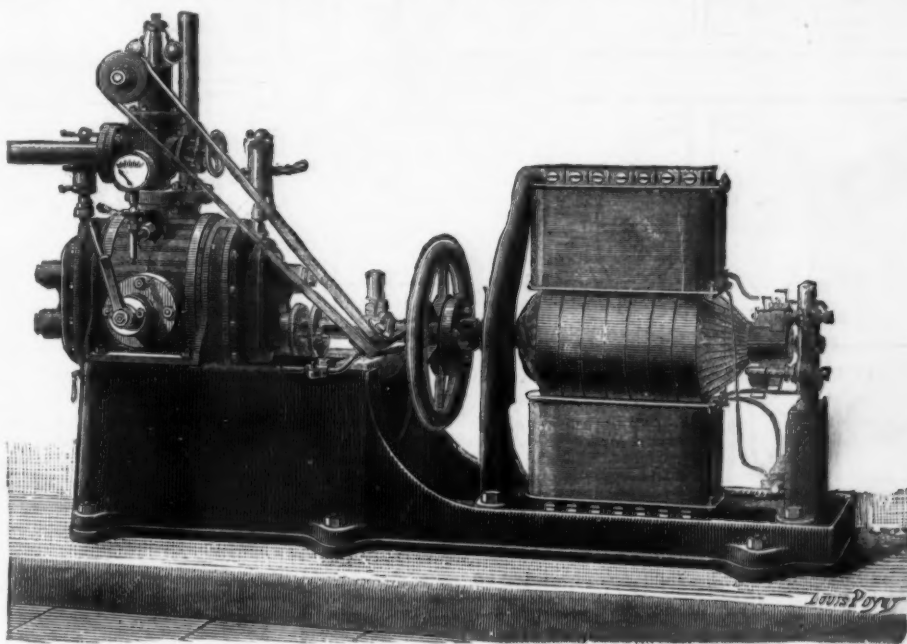
Messrs. Siemens and Halske have recently published an article on this new road, and have pointed out the advantages possessed by this mode of locomotion. Some of the prominent arguments which they advance in favor of it are as follows:

The motor necessary—steam or atmospheric pressure—not being placed on the car, the latter is consequently not obliged to carry a very heavy, inert load. The car can, therefore, be of a lighter construction, and, as a conse-

quency, but such as it is now, and such as it proved itself to be on the occasion of the experiments at Lichterfelde in May, is enough to show that it is certain of a brilliant future.—*La Nature*.

LINKS IN THE HISTORY OF THE LOCOMOTIVE.

In Smiles' "Lives of the Engineers," in the volume of the 1874 edition devoted to George and Robert Stephenson, will be found a very small engraving, which is a longitudinal section of Murdoch's locomotive. In the "Life of Trevithick," by his grandson, and published by Messrs. Spon, in 1873, will be found a small section of the machine. We are not aware of the existence of any other section of this little engine, save that which we publish on next page. The machine is the property of Mr. Murdoch, manager of the Sun Foundry, Leeds, and grandson of William Murdoch, the friend of Watt, and the maker of the little locomotive in question. Smiles gives no dimensions or details. Mr. Murdoch has, however, recently taken the engine to pieces, and had a drawing made from it fully dimensioned, and we are



STATIONARY STEAM ENGINE COUPLED TO THE SIEMENS DYNAMO-ELECTRIC MACHINE.
FIG. 1.—THE ELECTRICAL RAILWAY OF GROSS-LICHTERFELDE.

quence, the motive force can be diminished, thus effecting great economy in the cost of rails, chairs, bridges, etc., in constructing the road. The dynamo-electric machine fixed to the car is light in comparison with the service it performs, and may be applied directly to any car whatever. With it there is connected neither danger nor inconvenience. The lightness of the whole affair permits of the train being stopped easily while in motion and facilitates the working of the brake. The use of stationary steam engines in the exploitation of electrical railways presents another advantage—the boiler can be heated more surely and the steam be better utilized. This is especially manifest when the power of the stationary steam engine for actuating the dynamo machine increases.

In this system of railways a natural hydraulic power may be used, and there is no necessity of this being in the immediate vicinity of the road. There is no other system in which the use of fuel may thus be dispensed with.

When there are double tracks the machine which produces the electric current may furnish each of them with the impelling power that it requires. By taking proper measures two or more cars may form a train on the same track, or run singly at stated intervals.

This system is undoubtedly still susceptible of numerous

improvements, but such as it is now, and such as it proved itself to be on the occasion of the experiments at Lichterfelde in May, is enough to show that it is certain of a brilliant future.—*La Nature*.

The Murdoch model has been exhibited many times, and it is to be regretted that it does not now repose in some museum where it could be seen, while it remained in perfect safety. It consists of a flat board, at one end of which is a wooden upright, on which is pivoted a wooden beam.

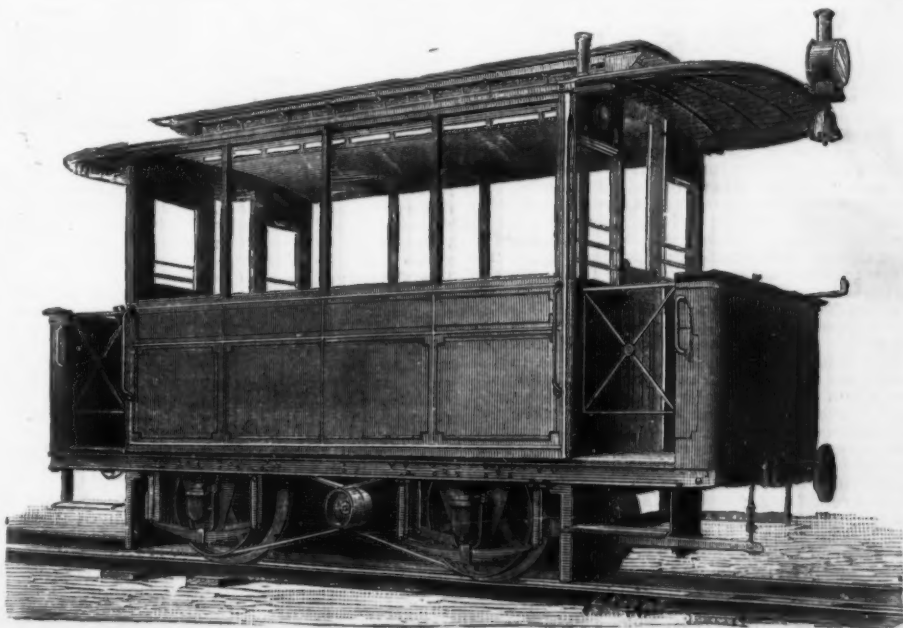


FIG. 2.—CAR OF THE ELECTRICAL RAILWAY.

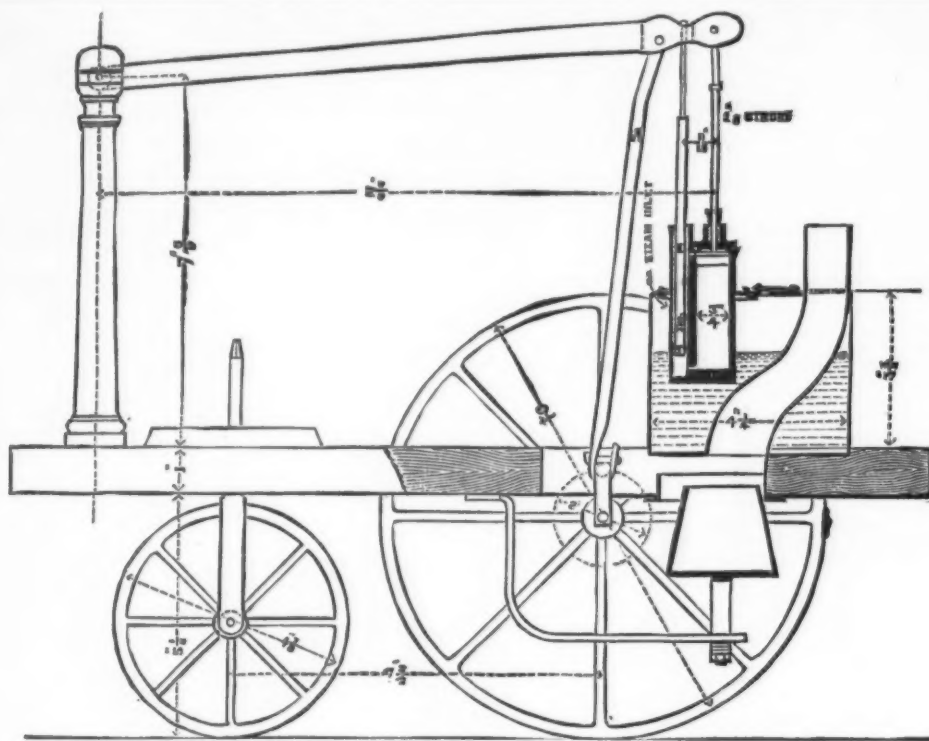
4. Map showing Position of Tunnel.
8. Going down in the Bucket.

3. Ferry for Vehicles (present means of crossing).
7. Working at the Bottom of Shaft, showing Entrance to Heading.

2. Passenger Ferry (present means of crossing).
6. View of Birkenhead Works, showing Headgear, Engine-house, &c.

THE MERSEY RAILWAY TUNNEL: PLAN AND SECTION, AND WORKS IN PROGRESS.

1. The Mersey, showing Section of Tunnel, Driftway, and Shafts.
5. Working at the Face of Heading.



LINKS IN THE HISTORY OF THE LOCOMOTIVE.—MURDOCK'S LOCOMOTIVE, 1784.

The cylinder is placed underneath the other end of this beam. This slide valve is actuated by a tappet motion, the beam striking it up and down alternately at each end of the stroke. The connecting rod has a transverse joint near the top, intended, no doubt, to compensate for imperfect workmanship, in the same way that Watt used a universal joint in his earlier connecting rods, as may be seen, for instance, in a Watt engine which is, or was until a very recent date, at work at Messrs. Frost's rope works in Bermondsey. The disk seen round the vertical pivot of the steering wheel is a leaden weight, apparently put on to keep the front of the engine down, and so make it steer better. The boiler is of copper. The details are too clearly shown to make further description necessary.—*The Engineer*.

TURQUOIS OF NEW MEXICO.

By B. SILLIMAN.*

The existence of turquoise, a comparatively rare gem, in New Mexico, is a fact long known. The chief locality is at Mt. Chalchuil, in Los Cerillos, about twenty-two miles south-west of the ancient town of Santa Fé, the capital of that territory. We are indebted to Professor Wm. P. Blake for our first detailed notice of this ancient mine, in an article published in the *American Journal of Science* in 1857.

It was subsequently visited by Dr. Newberry, who mentioned it in one of his reports, and also by others. I have lately had an opportunity of examining this very interesting locality, since it has been laid open in the old workings and thus rendered accessible to observation by the recent explorations of Mr. D. C. Hyde.

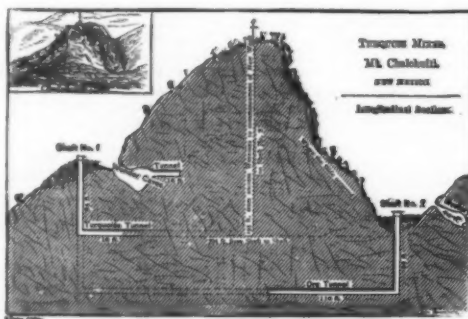
The Cerillos Mountains have recently come into notice from the partial, and as yet superficial, exploration of very numerous mineral veins which are found to intersect them, and which carry chiefly argentiferous galena, with some gray copper rich in silver, giving promise of mines of value when opened in depth. I have elsewhere spoken more particularly of these veins and of the rocks that contain them.

These rocks are all eruptive rocks of the family of the augite trachytes, the kind which, the world over, carries the richest and most permanent ores of silver, with some gold. In the center of this district, which is not more than about six miles by four in extent, rises the dome of Mt. Chalchuil (whose name the old Mexicans gave to the turquoise, its much valued mineral), the summit of which is about 7,000 feet above tide, and is therefore almost exactly on a level with the Plaza of Santa Fé, across the valley of the river of that name, to the northeast. In the other direction this mountain has its drainage into the valley of the Galisteo, which forms the southern boundary of the Cerillos district. The age of eruption of these volcanic rocks is probably Tertiary. The rocks which form Mt. Chalchuil are at once distinguished from those of the surrounding and associated ranges of the Cerillos by their white color and decomposed appearance, closely resembling tuff and kaolin, and giving evidence to the observer familiar with such phenomena of extensive and profound alteration; due, probably, to the escape through them, at this point, of heated vapor of water and perhaps of other vapors or gases, by the action of which the original crystalline structure of the mass has been completely decomposed or metamorphosed, with the production of new chemical compounds. Among these the turquoise is the most conspicuous and important. In this yellowish-white and kaolin-like tuffaceous rock the turquoise is found in thin veinlets and little balls or concretions called "nuggets," covered with a crust of the nearly white tuff, which within consist generally, as seen on a cross fracture, of the less valued varieties of this gem, but occasionally afford fine sky-blue stones of higher value for ornamental purposes. Blue-green stains are seen in every direction among these decomposed rocks, but the turquoise in masses of any commercial value is extremely rare, and many tons of the rock may be broken without finding a single stone which a jeweler or virtuoso would value as a gem.

The observer is deeply impressed on inspecting this locality with the enormous amount of labor which in ancient times has been expended here. The waste or *débris* excavated in the former workings covers an area, which the local surveyor

assured me extends by his measurement over at least twenty acres. On the slopes and sides of the great piles of rubbish are growing large cedars and pines, the age of which—judging from their size and slowness of growth in this very dry region—must be reckoned by centuries. It is well known that in 1680 a large section of the mountain suddenly fell in from the undermining of the mass by the Indian miners, killing a considerable number, and that this accident was the immediate cause of the uprising of the Pueblos and the expulsion of the Spaniards in that year, just two centuries since.

The accompanying vertical section of the mountain from east to west will give a good idea of the old workings, and of the shafts and tunnels projected and partly carried out by Mr. Hyde. The irregular openings, named by Mr. Hyde "wonder caves" and the "mystery," are the work of the old miners, and the whole hillside, from the flagstaff to the "mystery," was worked out by them also. It was this sharp slope of the mountain which fell. In these chambers, which have some extent of ramification, were found abundantly the fragments of their ancient pottery, with a few entire vessels, some of them of curious workmanship, ornamented in the style of color so familiar in the Mexican pottery. Associated with these were numerous stone hammers, some to be held in the hand and others swung as sledges, fashioned with wedge-shaped edges and a groove for a handle. A hammer, weighing over twenty pounds was found while I was at the Cerillos, to which the myth was still attached, with its oak handle—the same scrub oak which is found growing abundantly on the hillsides—now quite well preserved after at least two centuries of entombment in this perfectly dry rock.



The stone used for these hammers is the hard and tough hornblende andesite, or propylite, which forms the Cerro d'Oro and other Cerillos hills. With these rude tools and without iron and steel, using fire in place of explosives, these patient old workers managed to break down and remove the incredible masses of these tuffaceous rocks which form the mounds already described.

That considerable quantities of the turquoise were obtained can hardly be questioned. We know that the ancient Mexicans attached great value to this ornamental stone, as the Indians do to this day. The familiar tale of the gift of large and costly turquoise by Montezuma to Cortez for the Spanish crown, as narrated by Clavigero in his History of Mexico, is evidence of this high estimation. It is not known that any other locality in America has furnished turquoise in any quantity—the only other place thus far reported outside of Los Cerillos being that near Columbus District in Nevada, discovered by Mr. J. E. Clayton, and this is not yet worked.

The origin of the turquoise of Los Cerillos in view of late observations is not doubtful. Chemically it is a hydrous aluminum phosphate. Its blue color is due to a variable quantity of copper oxide derived from associated rocks. I find that the Cerillos turquoise contains 3.81 per cent of this metal. Neglecting this constituent, the formula for turquoise requires: Phosphoric acid 32.6, alumina 47.0, water 20.5 = 100%.

Evidently the decomposition of the feldspar of the trachyte furnishes the alumina, while the apatite, or

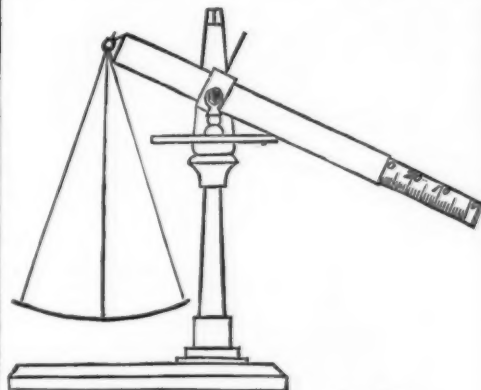
phosphate of lime, which the microscope detects in thin sections of the Cerillos rock, furnished the phosphoric acid. A little copper ore is diffused as a constituent of the veins of this region, and hence the color which that metal imparts.

The inspection of thin sections of the turquoise by the microscope, with a high power, detects that the seemingly homogeneous mass of this compact and non-crystalline mineral consists of very minute scales, nearly colorless, having an aggregate polarization, and showing a few particles of iron oxide.

The rocks in which the turquoise occurs are seen, by the aid of the microscope and polarized light, in thin sections, to be plainly only the ruins, as it were, of crystalline trachytes; they show fragments of feldspar crystals, decomposed in part into a white kaolin-like substance, with mica, slag, and glassy grains, and quartz with large, fluidal inclusions, looking like a secondary product. There is considerable diversity in aspect, but they may all be classed as trachyte-tuffs and are doubtless merely the result of decomposition, as already indicated, of the crystalline rocks of the district along the line of volcanic fissures. In fact there are, in a northerly direction, other places, one of them at Bonanza City, probably two or three miles distant, where the same evidence of decomposition is found, and in the rocks at this place I found also the turquoise in forms not to be distinguished from those of the old mine. Mr. Hyde has shown me lately in New York a large number of the Cerillos turquoise polished, one of huge size; and among them a few of good color and worthy of consideration as gems, some of them an inch in length and quite thick, but they are not of faultless beauty.

TUBULAR DISPENSING BALANCE.

DR. JOHN GORMAN, of Tunbridge, England, suggests a form of balance for prescription purposes, in which a rod



GORHAM'S DISPENSING BALANCE.

or tube sliding within a tubular arm replaces an external movable weight, as shown.

A NEW LACTOMETER.

For the accurate determination of fat in milk, gravimetric methods have heretofore alone given reliable results, while the legitimate use of lactometers has chiefly been confined to examinations made with a view to ascertain whether a certain kind of milk was above or below a given standard. Prof. Soxhlet, of Munich, has now constructed an apparatus which permits reliable results to be obtained also by the lactometer. The cooler or condensing tube, A, which may be revolved about its axis, contains a narrower glass tube, B, within which is placed the lactometer, C.



SOXHLET'S LACTOMETER.

The lower bulb of the latter carries three projecting points to prevent it from closing the lower orifice. Upon the scale of the lactometer are marked degrees running from 48 to 66, corresponding to the spec. grav. 0.748 to 0.766 at 17.5° C. The lactometer is also provided with a thermometer, graduated in one-fifths, and permitting one-tenth of a degree to be distinguished. To B is attached the flexible tube, D, the other end of which is connected with the tube, E, as shown in the figure. A shorter tube F, which enters the flask, D, is connected with a rubber blowing bulb. The flask, D, has a capacity of about 800 c.c. When using the apparatus, 200 c.c. of the milk to be tested, which must be made thoroughly uniform by stirring, are first introduced in the flask, then 10 c.c. of solution of potassa, and after thorough agitation 60 c.c. of water-washed ether, all at a temperature of 17.5° C. The flask is immediately stoppered,

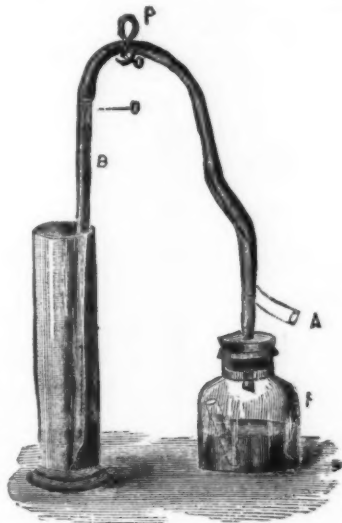
* Read before the American Association for the Advancement of Science, Boston, August, 1880.

thoroughly shaken, and set for some time (from one to two hours) in a vessel of water of the same temperature. On standing, the ether will rise to the top, and will contain all the milk-fat in solution. By gentle blowing with the bulb, C, the ethereal layer is driven through the tube, D, into the glass tube, B, where it will cause the lactometer to float as soon as a sufficient quantity has entered. The pinch cock in the flexible tube, D, having then been closed, the tube, B, is likewise closed with a stopper. To preserve the temperature of the ether liquid, the wide outer tube, A, is previously filled with water. As soon as the spindle floats freely, and the temperature is correct, the degree on the scale is read off, for which purpose the lower curve of the meniscus is observed. If the above temperature cannot be obtained, it is necessary to add, for each degree of temperature above 17.5° C., one degree on the scale, and for every degree of temperature below 17.5° C., to deduct one degree on the scale. After the experiment the apparatus is washed out with ether and dried.

The reliability of the results obtained with this apparatus is shown by the fact that they differed from those obtained by gravimetric methods by only 0.07 per cent. The given proportions and temperature have been chosen after careful comparison with others, as those which are the most favorable to accurate results.—*Chemiker Zeitung*.

A NEW UREOMETER.

MR. CHAS. RENSON, JR., of Louvain, has devised the apparatus here described. Into a long, straight glass cylinder, E, a plain burette, B, divided in 50 c.c., and without stop-cock, is introduced, and its upper end connected with a rubber tube, provided with a pinch-cock, P. This tube is intended to be attached to a glass tube, V, projecting from the flask in which the reaction takes place. When using the apparatus, the cylinder, E, is nearly filled with water, and by gently releasing the pinch-cock, and by suction through the open end of the rubber tube, the water is caused to rise in the burette until it stands on a level with the 0 mark. The pinch-cock is then closed and the tube connected with the flask, F, which has previously been charged with a solution of hypobromite and a rubber tube containing a measured solution (5 c.c. or 10 c.c.) of the urine to be tested. The hypobromite solution is made by dissolving 65 gm. of caustic soda in 1,000 gm. of water, and



RENSON'S UREOMETER.

adding gradually 60 gm. of bromine. When everything is ready, the pinch-cock is first released, whereupon the column of water in the burette will slightly fall below the mark 0. The author directs that this diminution, provided it remain constant, should not be taken into account, but that, after the reaction has ceased, the volume of gas should be read off, beginning from the 0 mark. The reaction is brought about by the upsetting of the rubber tube containing the urea-solution, whereby the urea is decomposed with the evolution of nitrogen. When reading off the number of c.c. on the burette, the latter is to be lifted up until the water outside is on a level with that inside. The percentage of urea is calculated in the usual manner, but the author directs that 4.5 per cent be deducted from the result, as a correction for products of decomposition which accompany the nitrogen.—*Jour. de Pharm. d'Ann.*

EXPERIMENTAL DETERMINATION OF THE VELOCITY OF WHITE AND COLORED LIGHT.*

By DR. J. YOUNG, F.R.S., and Professor G. FORBES.

THE method employed in this research to measure the velocity of light resembled the method of M. Fizeau, subsequently employed by M. Cornu. A revolving toothed wheel is employed in the same way to alter the intensity of the light reflected from a distance. In the present method, however, there are two distinct reflectors instead of only one. They are separated by a distance of a quarter of a mile. The observing telescope and the two reflectors are almost in the same line. The observer sees two stars of light, which go through their phases with different periods as the toothed wheel is revolved at increasing speeds. One star is increasing, while the other is diminishing in intensity, with the increase of speed of the toothed wheel. The speed required to produce equality of the lights is determined by means of a chronograph.

By choosing such a speed as gives a maximum of one star at the same speed as a minimum of the other, a pair of observations eliminates all cause of doubt arising from varying brightness in the stars, and ratio of the width of a tooth to the width of a space. The distances were observed by triangulation with the Ordnance Survey eighteen-inch theodolite, using as a base line a side of one of the Ordnance Survey triangles. The source of light was an electric lamp. The ve-

locities (uncorrected for rate of clock, and reduction to a vacuum) measured as follows:

187,707
188,405
187,676
186,457
185,788
186,495
187,003
186,190
186,830
187,266
188,110
188,079

Mean.... 187,167 miles a second.

The correction to vacuum is + 54 miles a second. The correction for rate of clock to a mean solar time is + 52 miles a second.

The final results for the velocity of the light from an electric lamp *in vacuo* is 187,273 miles a second, or 301,382 kilometers a second.

Using Struve's constant of aberration 20.445", we obtain for the solar parallax the value 8.77", and for the mean distance of the sun 93,223,000 miles.

On February 11, 1881, the reflected stars were seen to be colored, one reddish, the other bluish. The physical color of a particular star depended upon the speed of rotation of the toothed wheel. That star which was increasing with increase of speed of the toothed wheel was reddish, that one which was diminishing with increase of speed was bluish. This seems to be caused by the fact that blue rays travel quicker than red rays.

A number of tests were made to judge of the accuracy of this conclusion, and they confirmed it. In the final arrangements, the electric light was acted upon by a biphosphate of carbon prism, and part of a pure spectrum was used. Differential measurements were then made to find the difference in velocity of rotation of the toothed wheel, required to produce equality of red and of blue lights. The most convenient method was to use a driving weight slightly in excess of that required to produce equality of the light, then to fix to the pulley carrying the weights one end of a piece of stout India-rubber tubing, the other end being fixed to a point above. This gradually diminished the effective driving weight. The equality of red lights was first noted, the color of the light was changed, and the interval of time until the blue lights were equal was measured. The rate at which the India-rubber diminished the speed was afterward measured by the aid of the chronograph, and thus the difference of speed determined. The mean of thirty-seven determinations in this and other ways gave the result that the difference in velocity between red and blue lights is about one-eighth per cent. of the whole velocity, blue traveling most rapidly.

The general conclusion seems to be supported by a comparison of the velocity of light measured by M. Cornu and Mr. Michelson, where the source of light usually employed is taken into consideration. These are the only accurate measurements of the velocity of light hitherto published. They give us the following results:

	Usual source of Light.	Velocity in Kilos a Second.
Michelson's research...	The sun near horizon,	299,940
Cornu's "...	Lime light,	300,400
The present "...	Electric light,	301,382

Classifying the sources of light used by Cornu, we get the following approximate relative velocities:

Source of Light.	No. of Observations.	Approximate Relative Velocity.
Petroleum.....	20	298,776 kilos.
Sun near horizon....	77	300,242 "
Lime light.....	449	300,290 "

All these results seem to support the view that the more refrangible the source of light, the greater is the velocity. But the evidence of the present observations, indicating an excess of velocity for blue over red light, seeming to exceed one per cent. of the whole, must rest upon the merit of the present observations themselves.

MUSCULAR ACTIVITY AND DECOMPOSITION OF MATTER.

By DR. O. KELLNER.

THE requirement of an organism for the exertion of energy can become a cause of the decomposition of the components of the nutrient and of the body. Non-azotized materials are first attacked, and if such are insufficient or have been consumed a decomposition of the organized albumen takes place. This decomposition of the albumen of the body can only be arrested by an increase of food, especially of its non-nitrogenous portion. Even a very abundant supply of albumen cannot prevent the destruction of organized albumen if the total quantity of nourishment is not sufficient for the requirements of the force to be exerted. It is possible and probable that in consequence of the increased demand for oxygen during work a larger quantity of circulating albumen is necessary than the minimum required by the organism when at rest.

WICKERSHEIM'S PROCESS FOR THE PRESERVATION OF ORGANIC SUBSTANCES.

By H. STRUVE AND O. JACOBSEN.

THE original formula was 100 c.c. water, 40 c.c. glycerin, 10 c.c. methyl alcohol, 3.33 grammes alum, 0.83 gramme common salt, 0.40 gramme saltpeter, 2 grammes potash, and 0.66 gramme arsenious acid. The author points out that the alumina will be completely precipitated by the potash, and proposes in place of both alum and potash an equivalent quantity of potassium sulphate. The following two modifications of the fluid are now in use, the former for injections and the latter for steeping objects to be preserved:

Arsenious acid.....	16 grammes.	13 grammes.
Sodium chloride.....	80 "	60 "
Potassium sulphate.....	200 "	150 "
Potassium nitrate.....	25 "	18 "
Potassium carbonate.....	20 "	15 "
Water.....	10 liters.	10 liters.
Glycerine.....	4 "	4 "
Common methyl alcohol.....	3/4 "	3/4 "

* Abstract of a paper read before the Royal Society, March 19, 1881.—*Chem. News*.

WHAT IS GLUCOSE?

GLUCOSE is the sugar of the future. Oppose it as you will, it is daily increasing in importance and in the number of its uses. In climates where the sugar cane will not grow, and in countries where the sugar-beet cannot be cultivated with profit, there is a wide field for glucose. Wherever corn, grain, or potatoes thrive, there glucose factories will flourish. Glucose differs as much from cane sugar as tallow from lard, or butter from oleomargarine. Both kinds of sugar are sweet, although in a very different degree, and for many purposes one can be substituted for the other without the consumer being aware of the fact.

The manufacturers limit the term "glucose" to the thick sirup which neither solidifies nor crystallizes on long standing. The same substance in a solid state is called "grape sugar," but there is no chemical difference between the two. The name "grape sugar" owes its origin to the fact that a kind of sugar found in grapes and other sweet fruits has the same chemical composition as that made from starch by methods that we shall presently describe. This real grape sugar is often seen as an incrustation on raisins and figs. Honey also contains grape sugar, and it was there it was first discovered by Lowitz in 1792.

Cane sugar, whether obtained from the cane, from sorghum, from corn stalks, from the maple-tree, or from the sugar-beet, is identically the same, and when perfectly pure its origin cannot be determined by chemical or physical tests. Its composition is expressed by the formula $C_{12}H_{22}O_{11}$. It forms large crystals belonging to the monoclinic system, as is beautifully shown in rock candy. It is exceedingly permanent, and is incapable of undergoing fermentation until it has first been converted into glucose. In all these respects it differs from grape sugar. The latter has for its formula $C_6H_{12}O_6$. It crystallizes with more difficulty and usually in warty masses. It readily undergoes fermentation, splitting up into alcohol and carbon dioxide. It possesses the power of reducing copper, silver, and other salts, which cane sugar does not; yet it resists the action of cold oil of vitriol, which chars cane sugar at once. It is less soluble than cane sugar and about one-third as sweet.

Glucose can be made from any of the carbo-hydrates, starch, dextrine, cellulose, etc., but is generally prepared from starch. In this country corn starch is used, while abroad potato starch is preferred because it is cheaper.

In the manufacture of beer and spirits from grain of any sort the first operation consists in converting the starch of the grain into grape sugar, which is most readily accomplished by allowing the grain to germinate. The diastase then produced effects the desired conversion. Dilute acids have the same action on starch, and while almost any acid can be employed, even carbonic acid, glucose manufacturers generally prefer sulphuric acid.

The first part of the operation is essentially the same as in the manufacture of starch. The corn is soaked in water or dilute alkali, then crushed and washed on sieves as long as the water runs off milky. The starch is then allowed to settle, and the supernatant water drawn off. The next operation in making starch consists in drying it, but where the starch is to be converted into glucose this part of the operation can of course be omitted. The starch is next subjected to the action of very dilute sulphuric acid, in the proportion of two pounds of acid to 100 pounds of starch, and 300 to 400 of water. The water is first heated to boiling; the acid, diluted with three times its weight of water, is then poured in; and afterward the milky mixture of starch suspended in water is allowed to flow into the boiling acid. The first change that the starch undergoes is a conversion into dextrine. By long continued boiling this is changed into glucose. When one part of the liquid mixed with six parts of absolute alcohol no longer gives any precipitate of dextrine the boiling is stopped.

The next step in the operation is to neutralize the free acid. For this purpose lime, chalk, whiting, or marble dust may be employed. An insoluble sulphate of lime is formed, which is easily removed. It has been proposed to use barium carbonate for neutralizing the acid, as its sulphate is totally insoluble, whereas some of the sulphate of lime stays in solution. The cost of barium carbonate is an insuperable objection, and, being poisonous, its presence is less desirable than that of lime.

The sirup is now evaporated in shallow pans until it reaches a density of 1.13 (16° Baumé), which causes the sulphate of lime to be precipitated, while the other impurities rise as scum to the top. It is afterward filtered through bone-coal, and then evaporated to a greater or less extent, according as a sirup or a solid is desired. About twice as much acid is employed for making grape sugar as when glucose sirup is desired.

From the above description it will be seen that glucose, properly made, is in no way an objectionable article. It may disagree with some people, just as honey does, and for the same reasons. Persons who are troubled with dyspepsia, sour stomach, etc., often find difficulty in partaking of glucose, because it ferments so quickly in the stomach, as might have been expected. A German professor, Dr. J. Nessler, of Baden, has attempted to prove that glucose from potato starch contains a poisonous substance, but his method of isolating it might equally well have produced it. To remove all the glucose he added yeast to set up a fermentation, and when that was ended expelled the alcohol by boiling. His experiments were made with the unfermentable residue. Another gentleman, Mr. W. H. Langbeck, has proved that a bitter substance resembling colchicine is sometimes formed during fermentation. He has even succeeded in separating and crystallizing this bitter substance, and has described its reactions.

Some chemists claim to have discovered all sorts of poisonous substances in glucose, such as lead, tin, sulphuric acid, etc. We have not been so fortunate as to make any such startling discoveries. Of course, like every other manufactured article, much depends on the care taken in its preparation. The presence of sulphate of lime in very small quantities might be expected. Dextrine is often present in considerable quantity, but this is both sweet and wholesome, in fact highly nutritious.

The uses of glucose are very numerous, although it is seldom sold to the public under its real name; but under the alias of "golden drops," "sugar-house sirup," "strained honey," and even Vermont maple sirup, its sale is very extensive. It is largely employed by confectioners for making candies, by wine-dealers for strengthening wine, by brewers to add body to their beer. Dr. Kedzie, of the Michigan Board of Health, reports that of seventeen samples of table sirup tested by him, fifteen contained glucose. Of twenty samples analyzed in Chicago, only one was unadulterated.

We give below the result of our own analyses of two specimens of American grape sugar obtained in New York city, and of two samples of candy obtained in Boston, one of

which, usually called French candy, contains about eight per cent. of glucose.

COMPOSITION.	Grape Sugar. I.	Grape Sugar. II.	Candy. I.	Candy. II.
Glucose.....	75.49	76.85	17.50	8.10
Water.....	11.53	8.16	....	....
Ash.....	0.66	0.26	....	....
Sulphuric acid.....	0.27	None.	Trace.	None.

A sample of maple sugar that we tested was found to be nearly free from glucose. It should here be remarked that glucose is often present in molasses and sirups that have not been adulterated, having been formed from the cane sugar by boiling; also, that there are other substances besides glucose which possess the power of reducing alkaline copper solutions.

We do not believe that pure glucose is an injurious substance when properly made, but to sell it under the name of cane sugar, when it is but one-third as sweet, is a fraud; and to charge the price of cane sugar, when it costs but three cents a pound to make it, is a swindle. That it pays to make it is evident from the fact that there are more than twenty glucose factories in this country turning out over one million pounds per day of grape sugar and glucose.—*Boston Journal of Chemistry.*

PRELIMINARY NOTICE OF A NEW VEGETABLE COLORING MATTER.

By SAM. P. SADDLER and WM. L. ROWLAND.

SOME months since our attention was drawn to a variety of wood, called *Beth-a-barra*, which had been recently imported from the west coast of Africa, and was much valued for its extreme toughness and its capability of receiving a high polish.

The wood is compact, very heavy, and in color very nearly resembles ordinary black walnut. On close examination, however, the interstices of the fibers are plainly seen to be filled with a yellow crystalline powder. In this respect it differs from logwood, burwood, camwood, and red sandal wood with which it was compared. In these woods the color is uniformly disseminated, the fiber appearing as if soaked in a solution of corresponding color. It resembles more closely the yellow coloring matter of rhubarb and of araroba, or goa-powder, which compound, chrysophanic acid, occurs also as a loose yellow crystalline powder in the interstices of the root. Special attention was, therefore, paid to its resemblances to this compound, as well as to those of the well-known dye woods mentioned above.

A cross-section of the *Beth-a-barra* wood appears very similar to the fernambouc and sappan woods, from which brasilin is obtained.* It bears very little resemblance, however, to the sections of logwood and the other therein-mentioned woods†.

The coloring principle was extracted from the shavings, or better yet, the sawdust and raspings of the wood, by heating with distilled water containing a little sodium carbonate. This produced a deep claret-red solution, which was then filtered. To the filtrate acetic acid was added in slight excess, precipitating the coloring matter in a fine flocculent condition; this was filtered, washed, and then dissolved in hot 80 per cent. alcohol, from which it crystallized upon cooling. By successive crystallizations the pure substance was obtained.

The material thus gotten was a tasteless, yellow compound apparently crystallizing in scales or needles. Upon examination under the microscope these plates are found to be made up of a series of flat prisms, joined laterally. The crystals are unchanged in dry or moist air, insoluble in cold water, very slightly soluble in hot water, but readily soluble in alcohol or ether. The presence of even a trace of alkali or alkaline carbonate also causes it to dissolve with deep claret-red color. The crystals melt at 135° C.

Two lots were prepared for analysis; one was dried at 100° C., and the other at 125° C.

Analysis of material dried at 100° C.

	I.	II.	Mean.
Carbon.....	68.75	68.70	68.77
Hydrogen.....	6.05	6.05	6.05
Oxygen.....	25.20	25.16	25.18
	100.00	100.00	100.00

Analysis of material dried at 125° C.

	I.	II.	Mean.
Carbon.....	75.82	75.90	75.86
Hydrogen.....	6.39	6.49	6.54
Oxygen.....	17.79	18.31	18.05
	100.00	100.00	100.00

The mean of the results of the analysis of that dried at 125° C. would give a formula $C_{17}H_{13}O_5$, or possibly $C_{17}H_{12}O_5$, while that dried at 100° C. would be $C_{17}H_{12}O_5 + 3H_2O$.

The accepted formula for hamatoxylin, the coloring material of logwood, is $C_{17}H_{11}O_5$, which would give 68.57 per cent. of carbon and 4.63 per cent. of hydrogen.

Taking the work done within the past few years on hamatoxylin as a guide, the action of numerous reagents was then tried upon the new coloring matter. We will give for comparison the results arrived at with hamatoxylin and then state our results with the *Beth-a-barra* color.

Sodium amalgam has no action upon hamatoxylin; with this coloring matter, however, we obtained, on treatment with sodium amalgam, a white compound, which under the microscope is seen to be crystallized in fine needles. The examination of this we reserve for a future communication.

A drop of nitric acid added to the ethereal solution of hamatoxylin in the cold rapidly oxidizes it; nitric acid oxidizes this coloring principle only when concentrated, and with the aid of heat, giving rise to a white crystalline compound, soluble in ether, which gradually decomposes on exposure to the air.

Hamatoxylin, when fused with potassium hydrate, yields pyrogallic acid; this material, on fusion with potassium hydrate, yields no pyrogallic acid.

When hamatoxylin is treated with ammonia solution and is allowed to stand in contact with the air for several days, an oxidation product is obtained*; the *Beth-a-barra* principle, treated in this manner for several days, shows no signs of any oxidation or change.

Reagents.	Brasilin.	Hamatoxylin.	Santalin.	Beth-a-barra.
Alkalies.	Claret-red sol.	Reddish-purple sol.	Claret-red sol.	Claret-red sol.
Acids—weak.	Orange ppt.	Pink solution.	Light red ppt.	Yellow ppt.
Acids—conc.	Yellow solution.	Pink solution.	Dark red sol.	Yellow sol.
Alum sol.	Crimson-red ppt.	Yellow solution passing into violet.	Santalin thrown out.	Coloring matter thrown out, does not combine with Al_2O_3 .
Lime water.	Crimson ppt.	Bluish purple ppt.	Reddish brown ppt.	Acts like alkalies.
Ferrous salts.	Purplish-black ppt.	Bluish-black ppt.	Reddish-violet ppt.	Fine reddish chocolate ppt.
Ferric salts.	Brownish-red ppt.	Black ppt.	Reddish-brown ppt.	Chocolate brown ppt.
Copper salts.	Purplish-red ppt.	Purple sol.	Red ppt.	Brown changing to yellow ppt.
Lead salts.	Crimson-red ppt.	Violet sol.	Reddish-violet ppt.	Brick red precipitate.
Mercuric salts.	Yellow ppt.	Yellow sol.	Scarlet ppt.	Orange yellow ppt.
Silver salts.	Yellow ppt.	Gray ppt.	Reddish-brown ppt.	Deep red ppt.
Tartar emetic.	Rose-colored ppt.	Purple sol.	Cherry colored ppt.	Orange ppt.
Stannous chloride.	Red ppt.	Purple ppt.	Red ppt.	Yellow ppt.
Sodium aluminate.	Claret-red ppt.	Purple ppt.	Red ppt.	Claret-red ppt.

It is a noteworthy fact that though this substance contains more hydrogen relatively than brasilin or hamatoxylin, it does not oxidize as readily, but is reduced more readily than either of these coloring compounds. The above table has been prepared, comparing the action of a series of reagents upon several of the common coloring principles with the results obtained with this coloring material. The brasilin and santalin were extracted directly from the woods with alcohol, and the other two were alcoholic solutions of the crystallized coloring matters.

The following references, all of them to papers in the "Berichte der deutschen chemischen Gesellschaft," show what has been done with the investigation of these vegetable coloring matters in late years: Franz Reim—"Ueber das Hamatoxylin," 4, p. 329; Adolf Baeyer—"Ueber das Gallein," 4, p. 457; E. Kopp—"Ueber Brasilin und Resorcin," 6, p. 446; C. Liebermann and O. Burg—"Ueber Brasilin," 9, p. 1883; Richard Meyer—"Verhalten des Hamatoxylin bei der trockenen Destillation," 12, p. 1392; E. A. Letts—"Ueber das Phthalcin des Hamatoxylin," 12, p. 1651.

A comparison of the *Beth-a-barra* coloring material with chrysophanic acid, the yellow coloring principle of rhubarb and goa powder, was then made in order to see what resemblance there might exist between the two.

Chrysophanic acid forms golden-yellow scales, melts at 162° C., forms deep red-colored solutions with caustic alkalies or ammonia, from which the acid is precipitated in yellow flakes on neutralizing the solution with acid. Caustic soda will extract the color from solutions of chrysophanic acid in ether, chloroform, benzol, or petroleum benzin, yielding deep red solutions; ammonia will extract the color from solutions in ether or petroleum benzin, but not from chloroform or benzol solution. An ammoniacal solution is precipitated lilac by acetate of lead and rose-colored by alum.

The *Beth-a-barra* color looks like chrysophanic acid, but fuses at 135° C.; forms solutions with alkalies like those of chrysophanic acid. Caustic soda and ammonia both will extract the color from solutions in ether, benzol, petroleum benzin, and chloroform. An ammoniacal solution is precipitated brick-red by acetate of lead, and no compound apparently is formed in alum solutions. Chrysophanic acid, when ignited with zinc dust, yields methyl-anthracene; this compound similarly treated yields phenol-like bodies with the odor of wood-tar cresote, and soluble in alkali with violet color. Finally, the percentage composition of this compound, before quoted, differs too decidedly from that of chrysophanic acid, which requires 70.87 per cent. carbon and 3.94 per cent. hydrogen.

Nor does the *Beth-a-barra* principle correspond exactly with chrysarobin, which Liebermann and Seidler found to be the chief constituent of goa powder. That compound dissolves in strong potassium hydrate solution with yellow color and green fluorescence. Its percentage composition moreover demands 72.29 per cent. of carbon and 5.22 per cent. of hydrogen. By heating with caustic potash solution in contact with air it is changed into chrysophanic acid.

The similarity of the *Beth-a-barra* principle in many of its reactions to these two compounds leads one to suspect a relationship. We hope to be able to settle what this relationship is shortly by fuller study of its reactions and derivatives.—*American Chem. Journal.*

CAUSE OF REDDENING OF CARBOLIC ACID.

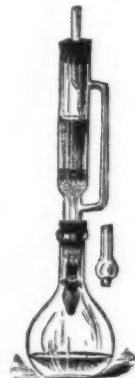
MR. ED. FABINI has observed that commercial carbolie acid, if brought in contact with copper or copper-alloys (brass, etc.), became red after a few days, and that its aqueous solution had acquired an acid reaction. On further examination, he found that the commercial acid had an acid reaction in nearly every instance, which probably facilitated the solution of minute quantities of the metal. Different specimens of the acid differed in the degree to which they became colored, and it was noticed that the color was least intense if the acid was warm. He, therefore, concluded that another agent participated in the reaction, and as Dr. Hermann Hager had ascribed the reddening to ammonia, he studied the effects of the latter upon his acid. On exposing some solution of ammonia under a glass globe, in presence of some slightly reddened acid, he found that the latter acquired an intense red color after twelve hours. One drop of ammonia added to carbolie acid contaminated with copper colored the acid dark red in three hours. And on adding one drop of solution of ammoniacal cuprous oxide or of ammonio-sulphate of copper to perfectly colorless carbolie acid, the latter turns dark-red in a few hours, and the tint is exactly identical with that of the commercial acid, which has gradually reddened apparently of its own accord. He, therefore, concludes that the reddening caused by ammonia is primarily due to the presence of traces of copper, which latter is probably derived

from the traces of copper contained in the coating of tinned iron vessels, in which the acid is usually brought in the market. Even very minute traces of copper appear to be sufficient to produce this result. It remains now to be shown whether spectrum analysis will be able to confirm the pre-

sence of copper in reddened carbolie acid.—*Pharm. Post and Pharm. Zeit.*, 1880, No. 101.

APPARATUS FOR CONTINUOUS DISPLACEMENT.

DURING the exhaustion of very finely powdered substances in the usual forms of extraction apparatus, in which the lower orifice is closed by a pellet of cotton or similar material, it happens not unfrequently that minute particles of the material are carried into the liquid, in consequence of which the latter has afterward to be filtered, which operation is usually attended with some loss of substance. On the other hand, if the pellet of cotton is compressed too much, or if the powder to be exhausted has been pressed down too tight, the rate at which the liquid percolates will not correspond with that at which it is redistilled, so that either the percolator will run over or the heat will have to be withdrawn for



WEIGELT'S APPARATUS.

a time. The introduction of small filters into the tube itself is not easy, and even if accomplished successfully, it frequently happens that the powder, packed imperfectly, will not be thoroughly exhausted.

Mr. C. Weigelt, of Ruffach, proposes, therefore, to modify the Zulkowsky-Wolffbauer extraction apparatus by attaching to the outlet of the percolator, within the flask, a small filter. Upon the lower end of the inner percolator-tube a slit cork is pushed (slit in order to permit an equalization of the vapor tension outside and inside of the filter), and upon this is fitted a small bulb attachment upon which is fastened the small filter.—*Report. d. Analyt. Chem.*, 1881, No. 1.

DENSITIES OF LIQUEFIED OXYGEN, HYDROGEN, AND NITROGEN.

By L. CAILLETET and P. HAUTEFUEILLE.

M. PICRET has drawn from the numerical data of his researches on the liquefaction of oxygen an approximate value for its density in the liquid state. The authors have made their observations upon liquefied carbonic acid, mixed respectively with liquefied oxygen, hydrogen, and nitrogen. The densities of these bodies when liquefied, taken at two temperatures, but at one and the same pressure, enable it to be established that their coefficients of expansion differ so little that the densities have the same respective proportion at 0° and at -23°. The densities have therefore been taken at temperatures and pressures at which these liquids are mutually comparable, and they render it possible to calculate the relations of the atomic volumes of these three bodies. These atomic volumes are 17 for oxygen, 30.3 for hydrogen, and 31.8 for nitrogen if we divide each of the atomic weights of these bodies ($O=16$, $H=1$, $N=14$) by its density at -23°, i. e., 0.89, 0.033, and 0.44. Oxygen, hydrogen, and nitrogen, when gaseous, deviate very unequally from the law of Mariotte at the pressures employed in the authors' experiments (275 to 300 atmospheres), and there exist no longer, under these conditions, simple relations between the atomic weights of these gases and their densities. But if a change of the state of aggregation is determined by a reduction of temperature it is found that the atomic volume of a body is a datum showing a positive relation between its density and its equivalent weight. If, as M. Stas holds, we cannot rely upon a law of condition for the determination of the true relation of the atomic weights, the atomic volumes lose their importance. But the atomic volumes which the authors have calculated deserve attention, even from this point of view, as furnishing numbers which are sensibly equal when they are not doubles of the atomic volumes assigned to their isomorphs. The atomic volume of nitrogen at -23° is about double that of phosphorus; these volumes would be about equal if we took the atomic weight of phos-

* *Amer. Journ. Pharm.*, p. 348, 1880.

† *Loc. cit.*, p. 351.

‡ *Ber. deutsch. chem. Gesell.*, 4, 239.

* *Handwörterbuch d. Chemie*, 3, 542.

† *Ber. d. deutsch. chem. Ges.*, 11, 1008.

phorus as 62.8. The atomic volume of hydrogen at -29° is a little more than double the atomic volume of magnesium to which M. Dumas has already compared hydrogen. If experiment shows that magnesium in the state of vapor has a density forty-eight times greater than that of hydrogen, a density anomaly observed in the nitrogen group, both in the gaseous and the liquid state, and ascribed to the splitting up of the molecule of nitrogen, would be repeated with the same characters in the group of which hydrogen is the first term. The atomic volumes of liquefied oxygen, hydrogen, and nitrogen differ much, as might be expected from those which have been deduced from the molecular volumes of compounds into which these elements enter. M. Kopp has given several atomic volumes for these bodies. His numerical determinations, combined with those which the authors have just completed, will render it possible to explain the correlative contractions of the principal compounds of these bodies, whether among themselves, or with those of the other elements which are known in the liquid or in the solid state.

JAPANESE DISTILLATION.

Mr. HENRY S. BRADY, at the last meeting of the British Pharmaceutical Conference, described a curious little earthenware distilling apparatus in use among the Japanese people in the country districts, where peppermint is largely used as a corrective for water rendered muddy and otherwise unsuitable for drinking by rains. It consists, as shown in the adjoining figures, of four pieces: a boiler, *a*, into which fits a short cylinder, with a perforated bottom, *b*, and over this a condenser, *c*, with a cover, *d*. The cover being removed, a stream of cold water can be kept running into the condenser by means of a bamboo, and the overflow car-

the receiver. In either case the condensed water is made to run back into the still, and the loss of the oil is, therefore, greatly reduced.

THE IMPURITIES IN WATER, AND THEIR INFLUENCE UPON ITS DOMESTIC UTILITY.

By MR. GEORGE STILLINGFLEET JOHNSON, M.R.C.S., F.C.S.*

THERE are some impurities found in the water of rivers, more especially in those rivers which, like that in the immediate neighborhood of this building, take their course through large towns, concerning which I shall have little to say this evening. I allude to organic impurities, the detritus of living beings, sewage, and the like; and my reason for keeping silence upon this great subject is the incompleteness of our knowledge regarding it. Our highest medical authorities seem to be at variance as to the nature and degree of the baneful influence exerted by those impurities which I have mentioned upon the human economy, with the exception of the so-called specific poisonous products of such diseases as typhoid and cholera; and our highest chemical authorities are very much at variance as to the best method of estimating or determining the amount of these organic pollutions in waters, as they also are in the various accounts they give of the processes by which nature removes them. It would ill become me, therefore, to do more than hint at the existence of this source of contamination of water, unless I stood prepared to bring forward some new facts or experiments throwing light upon the subject, which I am not in a position to do. I must, therefore, confine myself this evening to the discussion of some of the more important inorganic impurities contained in natural waters, and their influence upon the domestic utility of the important liquid which contains them.

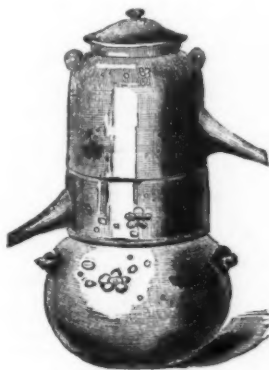


FIG. 1

JAPANESE STILL.

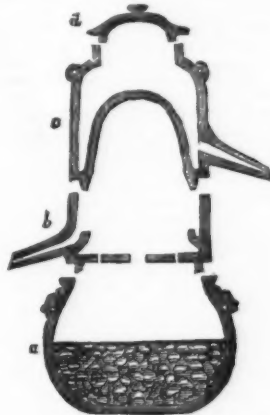


FIG. 2

ried off by the spout at its base. Round the base of the inner side of the middle cylinder runs a ledge which forms a channel opening into an exit spout. The materials for distillation are put into the boiler, and the whole is placed on the ordinary *hibachi*, or domestic fire-box. The vapor passes through the perforated bottom of the cylinder, collects in drops on the dome-shaped inner surface of the condenser, runs down into the channel before described, and is collected at its exit from the spout. This little contrivance is known by the Japanese under the name of *bumbiki* or *rambiki*, which is doubtless some corruption, through the Dutch, of the word alembic.

DISTILLATION OF ESSENTIAL OILS.

AMONG the smaller distillatory apparatus used in the manufacture of essential oils, one of the best is that of Drew, Heywood, and Barron. It consists of a double-walled boiler, surmounted by a still head, which is provided with a mechanism for keeping the contents of the boiler in motion (see Fig. 2). This stirring apparatus consists of a perpendicular shaft bearing a frame-work of iron curved so as to correspond to the interior shape of the still, and on the outside carrying a chain which scrapes over the inner surface of the still while the stirrer is being turned. This may be done either by hand or by steam. The still having been charged with the material from which essential oil is to be obtained, it is filled up with water to within a few inches of the top of the body of the still, and the latter is heated by admitting steam through the pipe, *S*. The vapors arising are conducted to a cooler situated at a level higher than the still itself, and the condensed liquid is collected in a receiver, where the oil and water separate. This receiver is provided with two faucets, one near the top and the other at the bottom. If the oil passing over is heavier than water, the excess of the latter is removed by the upper faucet; if the oil swims on the water, the lower faucet is regulated so as to allow the water to escape in about the same ratio as it enters

The word "impurities" has occurred several times already in this paper. I have also spoken of "pollutions" and "contaminations," all of which expressions tend to convey the idea that the presence of substances so described, in the water we drink and employ for household purposes generally must needs be injurious and prejudicial. Now, the tendency of this paper will rather be to show the great usefulness of many of these so-called "impurities" in natural waters; and the word is used here in its strictly chemical sense, to indicate anything which we find in and accompanying water which is not the chemical compound H_2O .

Pure water, the compound containing two atoms of hydrogen combined with one atom of oxygen, is a pure chemical substance which is never found in nature. We explain this by the statement that water exerts a solvent action upon various gases and solids. It is, then, by virtue of its solvent action that water becomes impregnated with the impurities of which I am to speak; and I will, therefore, ask you to follow me while I make a few preliminary remarks upon, and show you a few experiments illustrating the nature of solution. The process of solution consists essentially in a change of physical state, without alteration of chemical constitution. Thus, when sugar or common salt is dissolved in water, we can obtain the solid sugar, or chloride of sodium, by simply evaporating the water; and these are instances of true solution; but, if metallic copper be dissolved in nitric acid, that is an instance of solution accompanied by chemical change; for, if we evaporate the blue liquid thus obtained, we have a deposition, not of metallic copper, but of nitrate of copper, the salt formed by the chemical action which takes place between that metal and nitric acid. Solution proper, then, consists in a change of physical state simply, without change of chemical constitution. Now, we know of but three physical states in which matter can exist—the solid, the liquid, and the gaseous.

* A paper read before the "Applied Chemistry and Physics Section" of the Society of Arts, London, April 28, 1881.

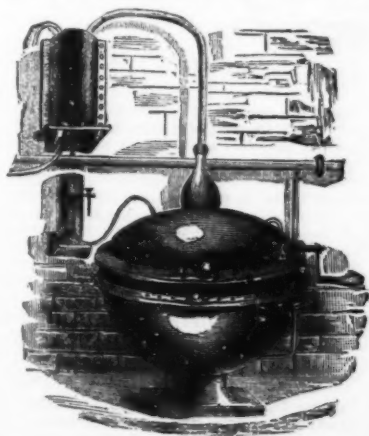


FIG. 1.

HEYWOOD AND BARRON'S STILL FOR ESSENTIAL OILS.

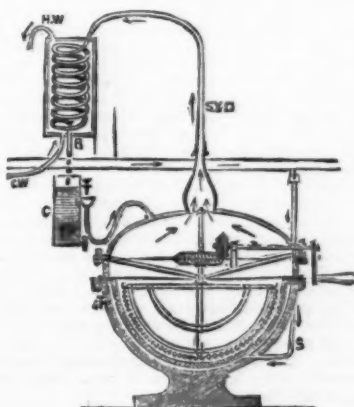


FIG. 2

The solvent, or substance which brings other substances into solution, is usually a liquid. The dissolved body may be either a solid or a gas.

The physical state in which we find any substance depends to a great extent upon the nature and intensity of the physical forces which happen to be acting upon it at the same time. Besides the action of solvents, the two physical forces, heat and pressure, exert a very powerful influence upon the physical state of matter. The essential difference between the three physical states of matter is one of the relative freedom of motion which exists between the molecules or ultimate particles of which the matter consists, the gaseous form of matter possessing the greatest, while the solid possesses the smallest degree of molecular mobility. Heat, on the one hand, increases this mobility of the molecules of matter, while pressure has the reverse effect.

Next, observe that the solvent (*e.g.*, liquid water) is in the intermediate condition, as regards molecular mobility, between the solid and the gas, whose physical state it must assimilate with its own before it can bring them into solution. It follows, then, that the liquid solvent must find a gas in chains, as it were—must diminish the free mobility which exists among the particles of that most elastic form of matter—while it will have to increase the molecular mobility of the comparatively sluggish solid, in order to make them respectively assume its own physical state. Accordingly, we should expect to find that a liquid will have its solvent action upon solids increased by the application of heat, while its power of dissolving gases will be diminished by heat, but improved by pressure. And these laws are obeyed in almost all instances.

I will now show you one or two experiments, to illustrate these preliminary remarks upon solution. When I stir up these two white powders in separate beakers of hot distilled water, you observe that one of them (which is powdered sugar) becomes readily incorporated with the water, changes its physical state, assuming that of its solvent, and is dissolved. This is an instance of a soluble substance. This other powder, however, refuses to do anything but remain partially suspended in the water, making the liquid look milky, while the greater part of it (for it is very heavy) sinks and remains in the bottom of the beaker. It is the salt called sulphate of baryta, and is one of the most insoluble bodies known.

To illustrate the effect of heat in assisting the solution of a soluble solid substance in a liquid, it will be sufficient to cool this hot saturated solution of iodide of lead; when we find that water which was capable of retaining a large quantity of this salt in the liquid state while hot, becomes incapable of doing so as it cools, and the excess of salt separates out from the solution in the crystalline form.

To demonstrate the action of heat in retarding the solution of a gas in a liquid, I will first pass up a little water into this tube, which contains dry ammonia gas confined over mercury. As soon as the water reaches the gas, you see that the latter disappears, being dissolved by the water. Now, if I pour a little hot water over the outside of the tube, we shall soon see the effect of heat in increasing the molecular mobility of the ammonia, for the restraining power of the water, at this high temperature, becomes insufficient to control the elasticity of its volatile companion, and the ammonia bursts its chains and resumes the gaseous condition. As the tube cools again, the solvent power of the water is again triumphant, and the gas disappears. Not only does the temperature of the liquid solvent exert an influence upon the quantity and quality of the substances which it is capable of dissolving, but the solvent action of a liquid is often considerably modified by the presence therein of substances which it has already dissolved.

We will consider this influence of dissolved matter in water upon its solvent action on other forms of matter somewhat fully, since it serves to explain the presence of some of the impurities found in waters; and it will be convenient to divide the subject into two heads, viz.: 1. The influence of dissolved gases upon the solubility of solids. 2. The influence of dissolved solids upon the solubility of other solids.

1. Excluding those cases in which a chemical action occurs, resulting in the production of some insoluble compound by the action of a dissolved gas upon one or other of the elements present in a dissolved solid, the general tendency is for a dissolved gas to increase the solubility of solids in their common solvent. As an illustration of this, I will cover this solution of copper sulphate with a strong solution of ammonia gas in water. You see now three layers in the containing vessel. Below, the blue solution of copper sulphate; above, the colorless solution of ammonia gas in water; and between the two a light blue turbid layer, the turbidity of which is due to the presence there of suspended hydrated oxide of copper, a substance which is insoluble in pure water, and in most neutral and alkaline solutions, but which is soluble in a solution of ammonia gas in water, yielding a dark blue liquid, which you see is produced when I stir up the contents of the beaker. There are other instances, which will occur to every chemist, of solid bodies quite insoluble in pure water, yielding to the solvent action of a solution of ammonia gas in water. It appears, then, that the dissolved gas confers a degree of molecular mobility upon the water which has dissolved it, or at least enables the water to produce the requisite freedom of motion among the molecules of an otherwise sluggish solid, which is necessary in order to compel it to assume the liquid state.

2. It is frequently observed, and especially among the halogen group of elements, that an insoluble salt is rendered soluble by the presence in their common solvent of a very soluble solid body. One of the most striking and beautiful examples of this is seen in the case of the red mercuric iodide, which is entirely insoluble in pure water, but is readily dissolved by water saturated with potassic iodide—a very soluble salt. It is essential that the potassic iodide be present in a somewhat concentrated solution, for, as you see in this beaker, when a solution of mercuric iodide in one of potassic iodide is mixed with a large bulk of pure water, the red mercuric iodide separates out. If there be any chemical action between the two iodides in this case, it is of the very feeblest kind. Indeed, some experiments of my colleague, Mr. J. M. Thomson, have tended to show that, if the double salts formed by dissolving insoluble halogen compounds in soluble ones be compounds at all, they are molecular, not atomic combinations. It is, at all events, interesting to remark, that when a dissolved solid assists the solution of another solid body, it is the more soluble substance—that which is endowed with freest molecular mobility—which serves to bring about the liquefaction of the more sluggish solid; and there are instances of this action which cannot be at all explained by chemical action, as in the case of the solubility of quick lime in a strong solution of sugar.

It sometimes happens that the action of a solvent is arrested by the formation of a protecting film of an insoluble

substance upon the surface of an immersed solid. Thus marble, which is a compact crystalline variety of carbonate of lime, is freely dissolved by a solution of hydrochloric acid gas in water, the only solid product of the accompanying chemical action being the salt known as calcic chloride. Now, calcic chloride is freely dissolved by water, and, as each particle of it is formed on the surface of the marble, it is dissolved off by the water, and fresh surfaces of marble are constantly exposed to the action of the hydrochloric acid. But if we immerse marble in water containing both hydrochloric acid and sulphuric acid in solution, its surface speedily becomes covered with an insoluble film of calcic sulphate, and the action ceases. Marble is still there in abundance; hydrochloric acid is also present in quantity adequate and sufficient for its solution; but, by reason of the intervening insoluble film of calcic sulphate, they are prevented from acting upon one another. "The chemical force can only act at infinitesimally small distances." Another instance of the protecting action of an insoluble film upon the surface of an otherwise soluble solid is seen in the case of the black ferrous sulphide. When this substance is acted upon by sulphuric acid, the salt known as ferrous sulphate is produced. Now, green vitriol, or ferrous sulphate, does not dissolve in cold, strong sulphuric acid, but it dissolves readily in hot, dilute sulphuric acid. When therefore, I pour cold oil of vitriol over this ferrous sulphide, there is little or no action, a film of ferrous sulphate forming on the surface of the sulphide, and protecting the sulphide beneath from the action of the acid; but when I pour water into the containing vessel, a brisk action is at once set up, heat being developed by the admixture of the water with the acid, cold strong sulphuric acid being converted into hot dilute sulphuric acid, which dissolves off the ferrous sulphate as fast as it is formed.

I will now pass on to a consideration of some of the impurities contained in natural waters—in water as it is supplied to us for use in everyday life—explaining, where this is possible, the sources and method of contamination, and, further discussing the chief precautions necessary for the removal of such impurities as are prejudicial to the domestic utility of this valuable agent. First, then, we will consider the gas found in solution in natural waters. With some trifling exceptions—viz.: some of the rarer mineral waters—the gases dissolved in water are those which are present in our atmosphere—oxygen, nitrogen, carbonic acid, and ammonia. The oxygen and nitrogen gases, the elementary constituents of the atmosphere, are present in it in invariable quantities, and are far less soluble than the other two.

The carbonic acid and ammonia, or compound gases, are chiefly products of animal life, and are constantly being removed by plants and vegetable organisms, but they are also more soluble in water than the first two. The carbonic acid is present in larger proportion than the ammonia, while it is also far less soluble than the latter gas. Indeed, after a long continued fall of rain, the presence of ammonia in the air of a place is hardly recognizable.

Spring waters are very apt to contain much larger quantities of CO_2 than rain water or river water. Meandering, as they frequently do, through subterranean passages, they are exposed in their course to influences peculiarly favorable to their conversion into strong solutions of this gas. The earth being the common receptacle for dead organic matter, and her cavities being in many cases never penetrated by the sun's rays, or ventilated in any way, accumulations of carbonic acid are to be expected in these regions. The water, then, which is often very cold (it may be produced by melted snows), is churned up at frequent intervals along its course with these terrestrial gases, and becomes, in consequence, highly charged with them.

We are able to demonstrate the presence of dissolved gases in water, by simply boiling it in an apparatus such as this which I now show you, and collecting the permanent gas which escapes, as is being done here. The presence of these dissolved gases in water appears to be in every way beneficial. If we consider water as a beverage, the sparkling and refreshing effect of spring water is largely due to the dissolved gas, especially to the carbonic acid gas which it contains. Again, boiled or distilled water, from which the gases have been expelled by heat, is mawkish and insipid, but may be again rendered palatable by aerating it with charcoal. But more than this, absolutely gas-free water (which, however, can only be obtained by boiling water *in vacuo*) boils at a temperature considerably above 100°C ., and with violent explosion.

Again, it is probable that the oxygen dissolved in water oxidizes, and removes some of the more readily putrescible organic matters contained therein; and it certainly is of the utmost importance to the life of fish. The dissolved gases in water also exert an important influence upon its solvent action for solids, as we shall now find. The solid substances dissolved in waters are generally chlorides, sulphates, and carbonates of the alkalies, and of the alkaline earth metals.

Those waters which contain the alkaline earths in solution are divided into (1) calcareous and (2) magnesian waters, the former containing sulphate or carbonate of lime in solution, the latter sulphate or carbonate of magnesia. Such waters are said to be hard. It is in the case of the carbonated calcareous and magnesian waters that we observe most distinctly the influence which a dissolved gas may exert in modifying the solubility of a solid in their common solvent. For the carbonates of lime and magnesia are insoluble in pure water, or nearly so; but considerable quantities of these salts may be brought into solution by water charged with carbonic acid gas. For instance, if I bubble carbonic acid gas through this clear lime water, we first observe a milkiness due to the formation of insoluble carbonate of lime; and on continuing to pass the gas, we finally obtain a clear solution. The dissolved gas enables the water to overcome the molecular sluggishness of the calcic carbonate, and to reduce it to the liquid condition; just as the dissolved ammonia gas in our previous experiment enabled the water to hold in solution the hydrated cupric oxide. Now, if I boil this clear solution of bicarbonate of lime, the excess of gas is expelled by the heat (just as the ammonia gas was expelled from its dissolving water when the temperature of the tube containing the solution was raised), and the water, no longer aided by the mobile carbonic acid gas, loses its power of keeping the calcic carbonate in the liquid state; accordingly this salt is reprecipitated.

Bearing these facts in mind, we shall be able to explain some of the phenomena of nature in connection with this subject of calcareous waters. We have seen that spring waters are frequently highly charged with carbonic acid gas. Now carbonate of lime, in the shape of chalk deposits and limestones of various kinds, is a very constant ingredient of the soil in many parts of the earth's surface. It must, therefore, be a matter of very frequent occurrence for water, already highly charged with carbonic acid gas, to come in contact with carbonate of lime in the course of its subter-

anean wanderings; hence the frequent contamination of natural waters with dissolved carbonate of lime. But there is another interesting and very beautiful phenomenon which we are enabled to explain by the light of the above facts. I mean the formation of stalactites and formations such as are figured in the diagram on the wall. Suppose a water holding in solution much carbonate of lime and carbonic acid gas to trickle slowly through the roof of a cave. From each drop of water, as soon as it finds itself exposed to the common air, some of its dissolved carbonic acid gas will begin to evaporate, and for each molecule of gas which thus leaves the water, a molecule of calcic carbonate will be deposited in the solid form. Let a few of these solid particles adhere to the roof of the cavern, and from the nucleus thus formed, the production of vast conical masses, such as are here portrayed with their beautiful tapering apices pointing toward the earth, is only a matter of time. The nature and quantity of the dissolved salts in spring water will, of course, vary with the composition of the soil through which it has passed. Many mineral waters are of great medicinal value.

We will next consider the influence of dissolved lime-salts upon the domestic utility of water. Is "hardness" in water prejudicial? If we consider the water as a beverage, the answer would be, "No." The worst that hard waters have been accused of is, that they produce a tendency to calculous formations in those who drink them. But I think the water-drinker may answer to that charge, "Not proven." And, on the other hand, we cannot but remember that the metals calcium and magnesium, in combination with phosphoric and carbonic acids, play the important part of conferring the requisite degree of hardness and stability to our frame—are, in fact, the earthy constituents of the skeleton. But there is another purpose for which water is employed—viz.: for washing—which is hardly less important than that we have just considered. For this purpose hard water is certainly disadvantageous.

Soap contains fatty acids, which form insoluble compounds with the lime and magnesia in hard waters, and no lather will be produced till all the lime and magnesia dissolved in the water have been precipitated in this way. And this occasions a waste of soap.

Now, what is called the temporary hardness in water may be removed by boiling it. The expulsion of the dissolved carbonic acid gas by this means leads to the removal of the calcic carbonate from solution in the water, and the hardness due to this cause is then removed. But the water may contain sulphate of lime in solution, which will not be removed by boiling the water. On the contrary, unless the water had been previously saturated with the salt, the evolution of steam in boiling would rather tend to concentrate its solution, and thus the permanent hardness due to this cause would remain. Moreover, there is a further objection to boiling water (except in small quantities) for the purpose of removing its hardness, since, besides the consumption of fuel which is necessarily incurred, the deposited calcic carbonate tends to form boiler incrustations, often of considerable thickness, upon the walls of the vessel employed for the purpose. And if they do not lead, as they have too often done, to dangerous accidents by their suddenly becoming detached, and producing explosive bursts of steam by allowing the water to come in contact with the strongly-heated metal wall of the vessel, yet must invariably cause great waste of fuel, owing to their inferiority as conductors of heat. Therefore, the process of Mr. Clark, which is conducted without any application of heat at all, was a great boon to mankind, especially as it has the additional advantage of clarifying a water as effectually as any filter.

The problem before us is essentially this: How may dissolved calcic (and magnesian) carbonate be best removed from solution in water? i.e., how may these salts be converted into suspended and insoluble matter with the smallest possible expenditure of time and money? We have seen that the method of boiling the water, though effectual, is objectionable on the score of expense, liability to accidents, etc. Now, in Mr. Clark's process, which I have said is preferable, the suspended insoluble calcic carbonate produced has to be removed by subsidence. There are two methods by which suspended matter is removed from water in nature—subsidence and filtration—and these processes are also adopted by man for the same purpose. Now it is claimed for the method of purification by filtration that organic matters are oxidized by the substances employed—e.g., charcoal, which has the power of retaining oxygen gas in its pores. But the process of Mr. Clark also undoubtedly removes dissolved organic matters from waters, the lime which is added acting as a mordant, and producing their precipitation. Mr. Clark's process is as follows: By adding quick lime or hydrated (slaked) lime to a carbonated calcareous water, the carbonic acid gas, which is holding the carbonate of lime in solution, is first removed by combination with the added lime, and the carbonate of lime thus produced falls, together with that previously in solution, as a solid insoluble precipitate. The turbid water is left to clear by subsidence, and is then drawn off freed from temporary hardness.

I have hitherto been speaking of what may be called unavoidable impurities in water—viz.: impurities which are introduced by natural processes which are beyond the control of man; but, before concluding, I must allude, however briefly, to a very important accidental source of contamination of water, which is sometimes introduced by man himself—I mean the contamination of water with lead. And here we shall find that the influence of dissolved matters in any water is extremely important in modifying its solvent action upon this metal. Lead, from the ease with which it is worked, and the resistance which it offers to atmospheric action, changes of temperature, etc., has been found to be a very convenient metal wherewith to construct pipes for the conveyance of water, and cisterns for its storage. But lead is dissolved in appreciable quantities by some natural waters, and the long-continued ingestion of the metal, even in very minute quantities, produces serious symptoms of diseases in the human subject, so much so that the metal has given its name to at least two specific affections—lead colic and lead palsy. It becomes, then, a matter of the utmost importance to be able to state, from a knowledge of the ingredients of any given water, whether or not it will be safe for persons to drink this water after it has been stored in leaden cisterns—whether or not the particular water is likely to exert any solvent action upon the metal. This we are able, in many cases, to do. For it has been found that pure water, free from both dissolved solids and gases, has no solvent action upon lead. But water containing dissolved oxygen becomes impregnated with lead, oxide of lead being, to a certain extent, soluble in water.

1. *Practical Deduction.*—Rain water, stored in lead, must not be used for drinking purposes. Again when waters containing carbonates, and especially sulphates, in solution, are stored in leaden cisterns, the metal becomes coated with

an insoluble protecting film of carbonate and sulphate of lead, further action being thereby prevented, and the water does not become saturnine.

2. *Practical Deduction.*—Carbonated and sulphated calcareous waters may with impunity usually be stored in lead; but the film which forms on the surface of the metal should by no means be removed.

3. Waters containing nitrates and chlorides in abundance cannot safely be stored in leaden cisterns, since the nitrate and chloride of lead are soluble salts. The practical deduction from this is obvious.

In concluding, I hope I have convinced most of my hearers that, though we do not drink pure water, it would be very much worse for us if we did, and that, while we may sometimes be inclined to ask, "Why is such a substance here?" we generally find at last that it serves some important purpose which had escaped our ken—in fact, that we are finally led to wonder at the wisdom which works through intricate and complicated labyrinths to a perfect and simple end, and are forced to admire the ultimate tendency and result of even such seeming anomalies as the "impurities in water."

AUTOMATIC WASHING OF PRECIPITATES.

UPON a retort-stand is fastened the pear-shaped vessel, B, having three tubulures, and lower down, the tray, M. N. The neck, a, of the glass vessel is connected, by means of a rubber tube, O. P., with a small glass tube, g. h. (Fig. 2), dipping in a small cup containing mercury. This cup is attached to one end of a small balance beam, p. r., the other end of which is counterbalanced by a weight (at p). At e, there is an axle bearing the bent lever, d. e. f. The disk, d. e, contains a circular ring in the middle, which is hinged in such a manner that a funnel placed in it will retain a perpendicular position during the rising or falling of the disk.

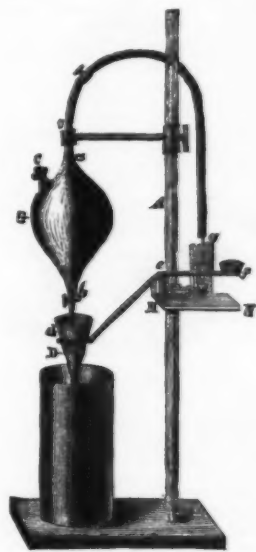


FIG. 1.

The other end of the lever, f, is provided with a cup, which is charged with a weight sufficient to counterbalance the other arm containing funnel, filter, and precipitate. The globe, B, having been filled with the wash fluid through the tubulure, e, the latter is corked tightly and the faucet below opened. At the same time, the lever, p. r., is set so that air will be able to enter through the lower orifice of the glass tube, g. h. As soon the funnel fills with water—and the proper height may be regulated by the balance weight—the disk, d. e, carrying the funnel sinks, and opposite arm, e. f, rises. To the latter are attached two wires, one of which carries a stirrup passing below the lever, p. r., the other having a similar stirrup reaching the top of the lever. As the

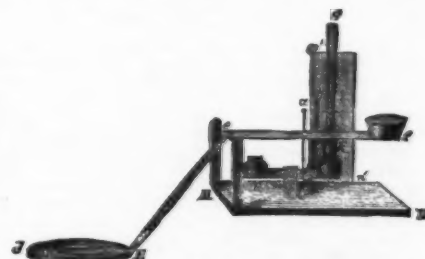


FIG. 2.

arm, e. f, rises, the stirrup at b (of the wire, a) raises the mercury cup until the end of the glass tube is closed by the mercury, when the flow of liquid from the globe, B, will cease. As the liquid runs from the funnel, the arm, e. f, will gradually descend again, and thereby depress the mercury cup, whereupon the flow of water will recommence. The two stirrups may be set at pleasure, higher or lower, so that the flow of liquid or the time at which the refilling of the funnel takes place may be regulated.—M. Andreeff, in *Ber. d. Deutsch. Chem. Ges.*

HEMO-CYANINE AND ITS DISTRIBUTION IN THE ANIMAL KINGDOM.

By C. F. W. KRUKENBERG.

BOTH in blue blood, containing hemo-cyanine and saturated with oxygen, and in the same rendered colorless by reduction, no characteristic distinctions are perceived with the spectroscopic. When the hemo-cyanine blood has been decolorized by carbonic oxide it is quickly rendered blue again if shaken up with atmospheric air.—*Med. Central-Blatt.*

ON THE CONDUCT OF FINELY DIVIDED IRON TOWARD NITROGEN.

By IRA REMSEN.

A RECENT writer* states that the method of Lassaigne for the detection of nitrogen in bodies containing carbon is not applicable to compounds in which sulphur is present. He claims that the sulphur gives rise to the formation of sulphocyanide, and that this is overlooked, as the solutions are strongly acid. A list of compounds is given in which nitrogen cannot be detected. It includes taurine, sulpho-urea, sulphocyanide of potassium, and the "amides of the sulphonic acids." In such cases it is recommended to fuse the bodies with sodium and pure iron, instead of sodium alone, as is customary. The sulphur forms sulphide of iron, and the nitrogen forms the cyanide and can easily be detected.

As I have repeatedly used the ordinary method for the detection of nitrogen in compounds containing sulphur, and have in some cases relied upon the results reached, I undertook an examination of the subject thus opened, and I have been led to conclusions directly opposed to those of the writer referred to. At the same time certain interesting observations have been made on the conduct of pure iron, reduced by hydrogen, toward nitrogen.

As regards the statement that the method of Lassaigne is not applicable to compounds containing sulphur, I am prepared to give this an unqualified denial. I have examined every one of the substances mentioned by the writer, with the exception of cystine, and have in each case without the slightest difficulty obtained the precipitate of prussian blue. I have also examined a large number of other substances, and have never experienced difficulty in getting the result looked for. Then, further, the fact that sulphocyanide of sodium or potassium itself breaks up under the influence of heat in the presence of an alkaline metal shows clearly that, even if this salt is formed as is claimed and as is probable, the detection of the nitrogen cannot be interfered with by the presence of sulphur.

Having shown beyond a doubt that the conclusion I had drawn with reference to a certain compound, that it contained no nitrogen, is correct, I nevertheless fused a small specimen of this compound with sodium and iron by hydrogen, and was astonished to find that, on extracting the fused mass with water, filtering, and then adding successively ferric and ferrous salts and hydrochloric acid, the blue precipitate revealing the presence of nitrogen was distinctly formed. I repeated the experiments a number of times, but always with practically the same result. In every case the blue precipitate was formed, though in some cases it seemed to be formed in larger quantity than in others. The variations in quantity were, however, not striking.

I now took other non-nitrogenous organic substances than the one which was in question and tested these. The two purest specimens in this laboratory at the time were one of the double tartrate of potassium and sodium which had been recrystallized a large number of times, and one of cane sugar which had been repeatedly recrystallized from alcohol. These two specimens may certainly be regarded as in the strictest sense chemically pure. Both of these substances gave the reaction for nitrogen distinctly. Of all the substances experimented upon, the pure double tartrate seemed to be best adapted to the purpose, and in continuing the experiments I have since always employed this particular pure specimen to furnish the carbon.

The question naturally suggests itself, whence comes the nitrogen in these reactions? I at first suspected the iron by hydrogen, and my suspicions were increased when, on inquiring into the history of the specimen used, I found that it had been made from ferric hydroxide precipitated by ammonia. To be sure the hydroxide had been washed with the greatest care, and had afterward of course been ignited in a current of hydrogen, and it did not seem probable that ammonia or any compound of ammonia and iron could be retained; but still, there was the nitrogen, and it appeared at least possible that it was actually contained in the iron. To test this point ferric hydroxide was precipitated from a solution of the pure chloride by means of sodium carbonate and washed out until no test for sodium could be obtained. This precipitate was then divided into two parts, one of which was dried at once, and the other boiled for some hours with a solution of ammonium carbonate and ammonia. The latter was then washed out, no special precautions being taken to remove all the ammonium salts, and afterward dried. Both specimens were separately reduced in a current of purified and dried hydrogen. Both gave the test for nitrogen, and indeed the one from which all ammonium compounds had been carefully excluded seemed to give the test better than the other.

Another specimen of iron by hydrogen which has been in the collection of chemicals of this laboratory for five years, and which does not take fire by contact with the air, failed to give the nitrogen test. This led me to think that possibly the nitrogen is not contained in the iron, but is absorbed from the air, and that the power to absorb nitrogen in this way is connected with the active condition of the iron. Both the specimens above referred to, which in the active condition readily and invariably gave the test for nitrogen, were allowed to stand for a short time in contact with the air and were then again tested. Neither gave the reaction. The same experiment was performed with the specimen of iron by hydrogen first used, and which had been preserved under ether. A portion of this was allowed to stand over night exposed to the air and then gave no indication of the presence of nitrogen. These results make it appear extremely probable that the nitrogen detected when active iron is used is really absorbed from the air. But if this is so, then more thorough contact of the heated reagents with the air ought to increase the quantity of cyanide formed. All the experiments thus far mentioned were performed in test tubes, and of course very little air came in contact with the substance at the bottom of the tube. On heating the necessary mixture in a crucible, however, violent combustion of the sodium took place and no reaction for nitrogen was obtained. To prevent this combustion, a mixture of iron by hydrogen, double tartrate of sodium and potassium and metallic sodium was placed in a hard glass tube, and dry hydrogen passed through while gentle heat was applied to drive off water. Then nitrogen was passed slowly over the mixture, while at the same time it was heated to redness. This process was continued for about ten minutes, when, on allowing the tube to cool, the contents were extracted with water, filtered, and treated in the usual manner. To my surprise, a very large precipitate of prussian blue was formed, much larger in proportion than in any previous experiment. The result is so striking that the experiment is well adapted to serve the purpose of a lecture experiment, illustrating the formation of cyanogen from the nitrogen of the air. There can be no

doubt that the nitrogen is really absorbed from the air. The quantity of the precipitate obtained in the last experiment was so great as to exclude the supposition that the nitrogen could have been present in the substances used. Then, further, the fact that the active iron, which readily gives the test for nitrogen, does not give the test after it has been exposed to the air and become oxidized, is a clear indication that the active condition of the iron is an important factor in the process, and that the nitrogen cannot be in combination with the iron. For, if it were, it is difficult to understand how the spontaneous oxidation of the iron could remove it. The heat evolved can scarcely be sufficient to decompose any nitrogen compound present, for the iron is heated to a much higher temperature in the course of its preparation, and the possible nitrogen compound must have been decomposed by this first application of heat.

I have thus far performed no quantitative experiments, and there are obvious difficulties in the way of making these exact. As it is intended soon to continue the experiments, however, an attempt will be made to determine as nearly as possible how much nitrogen can be taken up and combined chemically by given weights of the reagents. Some other points of interest will also be taken up. Thus, in attempting to exclude the air from the vessels in which the reactions took place, hydrogen was used, and the nitrogen test was not obtained. But on testing a nitrogenous substance (hippuric acid) in the same way, very little evidence of nitrogen was obtained. It would, hence, appear that the test cannot be applied in an atmosphere of hydrogen, or that the cyanide is decomposed when heated in hydrogen. On the other hand, Marchand* has stated that hydrogen does not interfere with the application of the test.

As a result of the experiments described in this paper, it may be stated with confidence that when iron by hydrogen and certain non-nitrogenous organic substances are heated together with metallic sodium in an atmosphere of nitrogen, a cyanide is readily formed. The action is, of course, similar to that which takes place in blast furnaces, and which gives rise to the formation of cyanide of potassium. In the latter case, the carbonate of potassium from the burning of the fuel furnishes the potassium. Nitrogen is always present in large quantity, and the iron is constantly passing from the state of oxide to that of the metal.

Marchand some years ago showed† that steel when heated with carbon and potassium can take up nitrogen. It had been previously stated by Schaffhäutl‡ that steel always contains nitrogen. The experiments of Marchand made this statement appear improbable though they did not disprove it. Indeed, later a discussion arose in France on the same subject. Fremy claimed that not only is nitrogen always present in steel, but it is the essential element of the steel. This discussion did not at the time lead to a satisfactory conclusion. Quite recently Müller§ has found nitrogen in not inconsiderable quantity in the gases extracted from Bessemer steel by boring, but thus far he has not been able to determine whether the nitrogen is simply inclosed in the pores of the steel or is chemically combined with it.

I have made a number of experiments with Bessemer steel and with other forms of iron, and have obtained results in accordance with those already on record. It seems possible that as regards steel the nitrogen detected may be partly absorbed from the air and partly present in combination with the iron, though it would be difficult to prove the correctness of this supposition.—*Amer. Chemical Journal*.

SPONTANEOUS IGNITION OF COAL.

By H. HAEDICKE.

RICHTER's experiments tend to show that the decomposition of coal in the presence of moisture depends on the pyrites, while the destructive action of oxygen occurs only at an elevated temperature, and is checked by the presence of moisture. The influence which pyrites may exercise on the decomposition of coal is of a twofold nature. It becomes first oxidized by the co-operation of moisture, and is transformed into ferrous sulphate; and during its formation the coal becomes split up and exposes a larger surface to the air; this ferrous salt is then oxidized into the ferric salt, which gives up oxygen to the coal.

These assumptions throw some light on the causes of spontaneous ignition, which are mainly attributable to the action of pyrites. The author found that pyrites ignites in pure oxygen at a temperature of about 200°. He attaches great importance to this subject, and gives some statistics as to the occurrence of accidents through spontaneous ignition—no less than 70 accidents were recorded among 31,116 ships in 1874 as resulting from this cause. To prevent spontaneous ignition, it is especially requisite to exclude all currents of air, unless the latter is passed through from the commencement in a strong current so as to act as a cooling agent. As moisture prevents ignition and accumulation of oxygen, it is desirable to introduce a jet of steam if there is any great increase of temperature in the coal.—*Dingl. polyt. J.*

OZONE.

EM. SCHÖENBEIN calls attention to the fact that, since the existence of hydrogen superoxide in the air has been demonstrated, the occurrence of ozone as a constituent of the atmosphere has become very doubtful. Most of the reactions formerly relied upon for the detection of ozone are also produced by hydrogen superoxide. The latter liberates iodine from the iodides and oxidizes thallous compounds. It does not oxidize manganous salts, but such oxidation cannot be regarded as an evidence of the presence of ozone, since ordinary oxygen in the presence of carbonate of ammonium—which is always to be found in the air—will effect it. The tarnishing of silver may be, and probably always is, due to the presence of sulphides. The odor sometimes observed and ascribed to ozone is at best a questionable argument for its presence. Most observers would be liable to confound the odors of ozone and hyponitric acid. Moreover, ozone is not produced by the electric spark in a mixture of oxygen and nitrogen, but only oxide of nitrogen, hence the fact of visible electric discharges in the air is no evidence of its formation. It is produced by the silent discharge, but of this, as an atmospheric phenomenon, we still know too little to justify us in regarding it as a probable source of supply.

* Journal prakt. Chemie, 49, 355.

† Loc. cit.

‡ Ibid., 19, 409.

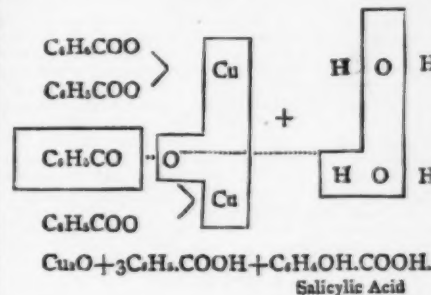
§ Berichte deutsch. chem. Gesell., 14, 1.

| Berichte d. deutsch. chem. Gesell.—*Amer. Chem. Jour.*

SYNTHESIS OF SALICYLIC ACID.

By EDGAR F. SMITH, of the Laboratory of University of Pennsylvania.

UPON heating one part of copper benzoate with about three parts of distilled water in a sealed tube at a temperature of 180° C., for a period of three hours, a large quantity of cuprous oxide separated. The contents of the tube were then removed to a rather large beaker, acidulated with hydrochloric acid, and the solution supersaturated with hydrogen sulphide. The filtrate from the copper sulphide contained, of course, a considerable amount of benzoic acid, which was removed by distillation in a current of steam. The residual liquid reduced to a small volume gave a crystallization of needles, fusing constant at 136° C., and afforded with ferric chloride the characteristic coloration given by salicylic acid. The salts also proved the presence of the latter. The reaction, then, described above may be graphically represented as follows:



The experiment repeated gave the same result. A quantity sufficient for analysis was obtained, although its separation from the benzoic acid was attended with difficulty. In one or two instances the method was slightly modified. An aqueous solution of benzoic acid and an ammoniacal solution of cupric oxide were employed. The mixture was heated as usual, but it was necessary to increase the temperature to 220° C. The yield of salicylic acid in either case was never very abundant.—*Am. Chemical Journal*.

ON A PURE COKE.

By W. W. STAVELEY.

I HAVE recently had occasion to test a sample of coke, made from coal-tar pitch, which I found to contain a very small percentage of sulphur. Since it is not generally known that coke of such purity is obtainable in large quantities, it may be well to record the analysis:

Sulphur.....	0.13	0.11
Ash.....	2.43	2.50
Carbon.....	97.45	97.39 by difference.

The sulphur was estimated by the prolonged boiling of the powdered coke, 5 to 6 grms., with nitric acid and a little chloride of potash. The ash was estimated by heating for several hours in a Fletcher's muffle furnace at a white heat. The sample of coke was taken from the ovens and powdered while hot, thus insuring the absence of moisture. Several determinations of sulphur and ash were made with similar results. A noticeable feature of this coke is that on exposure to the weather, even for months, it does not "slack" or disintegrate. This is no doubt due to the small percentage of sulphur present, the cause of the slacking of most cokes—gas-cokes especially—being attributable to the oxidation of the sulphides of iron contained in the coke. The heating and burden carrying power of this coke in the furnace far exceeds that of the best Durham coke. From its hardness and close texture it is especially calculated to resist the action of the hot gases on the upper portion of the furnace, thus diminishing the loss.—*Chem. News*.

SODIUM AND POTASSIUM CHLORIDES IN MINERAL ANALYSES.

By DR. FR. MUCK.

THE author remarks that these chlorides often accumulate to a serious extent and prove very inconvenient. He evaporates the filtrates containing magnesia (whether before or after the precipitation of the lime) almost to dryness, covers the residue with cold, fuming hydrochloric acid, stirs well, waits a few minutes, decants repeatedly through a filter formed of glass beads and cotton, and finally washes the saline mass upon the filter completely with strong hydrochloric acid. The residue obtained after evaporating the filtrate contains, in addition to magnesium chloride, very little fixed chlorides, and requires for its solution but a very small quantity of water. The use of glass beads containing lead must be carefully avoided, and also "glass wool," which apparently cannot be procured uncontaminated with lead.

OPHIOPHAGY.

THE KING SNAKE (OPHIOLIS SATI) SUPS ON A FULL GROWN WATER MOCCASIN (ANCIRODON PISCIVORUS).—"Be ye therefore wise as serpents."—Matt. x. 16.

The non-venom-secreting Ophiobolus and the deadly Ancistrodon had kept a friendly companionship for several days in the same prison box. Well aware of each other's peculiar method of self-defense, there had been a policy trace instituted for the nonce. The former did not relish a hypodermic injection of poison from his surgeon neighbor, and the latter equally as much dreaded a fraternal embrace from his acrobatic companion. The one abhorred convulsions and tetanoid calisthenics as much as the other deprecated triturated ribs and macerated scales. The sky became suddenly changed, and such a change! etc., etc. Byron. Without warning, the king snake instantly whipped a coil or two of its tail around the neck of his neighbor, just as the cracker of a whip doubles into a knot by the movement of the staff in the hands of a deft coachman. Before the moccasin could recover from the shock, its entire body was tightly pressed by the reduplicating folds of its agile enemy. From neck to tail and back again, its entire length was moved so effectually that respiration became difficult, movement of the body was out of question, excepting a vibrating tremor passing helplessly from nasal tip to tail tip, and a swift contracting of the assailant's convoluting folds assured the victim of broken ribs and speedy helplessness. The mouth

* Berichte d. deutsch. chem. Gesell., 10, 3516.

of the moccasin was open, though the bifid tongue could not dart forth, the lower jaw hung livid, and the strength left in the upper maxillary was insufficient to allow the poison fangs to erect themselves. Suffocation and broken ribs were too much even for a deadly snake to withstand. These facts were closely noted by our acute Ophibolus, who slowly uncoiled himself from the neck of the vanquished, and withdrawing his head a few inches so as to notice the features of his prey, he advanced for the banquet. The stunning blow being felt, the moccasin had closed his mouth, and was apparently resigned to his fate. Fastening his upper teeth upon the occipitals, and distending his os quadratum, the king snake held the head of his victim in his mouth, the tail of the latter still wriggling uneasily. The coiling became tighter and tighter, a slight noise like the crackling of bones was heard, accompanied by a tremor which shook both alike, and the two, victor and vanquished, now twisted up in a labyrinthine knot, rolled over and over like a spent ball from a cannon.

Taking them from the box, I uncoiled and stretched them out on the floor, where they appeared like a double tailed snake without a head. This gave relief to the moccasin who, although his head, as far as the atlas, was firmly held between the jaws of his antagonist, wriggled manfully with renewed strength obtained by release from the constrictor's folds. The king snake was now at a disadvantage, as noted from the movements of his tail. A stick was placed near it, around which it was instantly coiled to the extent of six inches, and with this purchase power he felt at ease. The ribs of the moccasin were effectually crushed, and the process of swallowing him was now easier and more rapid. About sixteen inches of the victim's body being stored away in the expanding stomach of the happy constrictor, a quantity of chloroform was administered to the gourmand, and in this position the two specimens are now preserved in my cabinet.

The length of the king snake was forty-two inches, and that of the moccasin thirty-four inches, the body of the latter being much larger than that of the former. The time occupied in this half-way repast was two hours.

Only a scientific consideration prompted me to destroy and dissect my useful cannibal, for he had already eaten seven other snakes while in captivity.

This note must be added. Ophiophagi, or snake eating snakes, prefer other victims, and prey on their own species only on account of the absence of their regular food.—John T. Humphreys, Burke Co., N. C., in Amer. Naturalist.

STREET-TREES AND PUBLIC GROUNDS.

THE best results in planting street trees are attainable when there is a concert of action by the entire community in relation to the subject. Such concerted action indicates considerable advancement, or a general spread of horticultural taste, and, naturally, the best examples of it might be expected to be found in the oldest parts of the country. But the migratory character of our people greatly modifies the formative conditions of society. The most enterprising and well-informed persons are often leaders in new communities, and exercise great influence in shaping their features; so, in some of the new towns and villages of the West, there are found handsome, broad streets and avenues lined with trees, and public squares and parks, while many of the older villages are yet as deplorably destitute in these respects as at their beginning.

During the summer season, with heat almost tropical, the shade of trees in passing along the streets is gratefully appreciated. What are the best trees for street-planting, and what the best modes of planting, are questions of general interest.

To say that street trees ought to be planted in the street may seem a superfluous statement; nevertheless, many a place would be the better if this simple rule had been observed. Formerly it was more customary than now to plant a row of trees along the fronts of lots, within a foot or two of the street-line. The advantage of thus placing trees is apparent, since they were there protected by good fences, and were thus secure against injury from horses and cattle. This security it is far better to obtain by proper guards to the trees when necessary; but, fortunately, in most localities, the necessity of protection no longer exists. The row of trees across the front rendered it almost, if not quite, impossible to plant the grounds with any effect in the modern style. The trees intended for shade of the sidewalk should, therefore, be always planted along its outer edge and next to the roadway. The first step to any improvement in many old grounds is to cut away the row of trees along the front.

While we plant trees on our grounds with special reference to the ornamental effects of their outlines and the beauty of their foliage, the primary object in street-planting is ample and lasting shade during the summer season. Our first inquiry, then, is how this object may best be secured. Trees are subjects of comparatively slow growth; a generation that witnesses the planting of certain trees may pass away and yet the trees be young and only partially developed. It is only natural and quite proper that the planter himself should desire to experience the benefit of shade from trees of his own planting. Keeping in mind the space required for their perfect development, and yet aiming at useful results as speedily as possible, it has become evident by long experience and observation that street-trees should be planted twice as close as it is proper for them ultimately to stand, and when necessary every other tree should be cut away. Planting the trees thus closely, eighteen or twenty feet would be proper distances; so that, at last, after thinning out, they shall stand thirty-six or forty feet apart.

Sugar maples planted thirty feet apart in good soil, and with all conditions favorable, will not touch the extremities of their most extended branches in twenty years from planting; they will not fairly fill the space in thirty years. If sugar maples should be planted twenty feet apart, and, when fifteen or twenty years old, every other one cut out, their heads would never form a close or compact row. This species of maple is the slowest-growing of our best street-trees, but it is also one of the best.

The American elm, although it has a fine spreading head, in its early years is apt to be straggling, having a few main branches with an open center, and giving but slight shade. Forty feet is not too great a distance for American elms when fully developed, but it requires many years to produce rows of them that will give the desired shade in midsummer on streets and avenues.

In employing either the sugar maple or the American elm, and planting the trees at the wide distances, thirty-six or forty feet, as has been supposed, a more rapidly growing tree with ample foliage planted immediately would in a few years greatly assist in producing shade. The silver-leaved maple, *Acer dasycarpum*, is well adapted to this pur-

pose, having good, broad foliage, a spreading head, and is a rapid grower. In fifteen or twenty years after planting, the silver maples should be cut out and the elms or hard maples allowed the full room. By adopting this method of planting a satisfactory amount of shade may be attained in the shortest time. Such desirable trees as the American elm and the hard maple will ultimately line the street. And they will then stand sufficiently far apart for their full development.

The American or white elm, *Ulmus americana*, with its full-formed, ample, over-arching head and drooping branches, is one of the handsomest and most serviceable of trees for the street. It is one of the most picturesque objects of our landscapes, exhibiting both grace and strength harmoniously united. We accede it the first place as a street tree. But it would not do to use any one kind exclusively; however beautiful it may be its charms will stale by continuous presence.

The English elm, *Ulmus campestris*, is a tree of rapid growth that ultimately attains a large size, of from fifty to seventy-five feet in height. It sends out its branches at a wider angle than the white elm, in fact, nearly horizontally, presenting an expression of grandeur and strength. It is truly magnificent in all its proportions. The wood of this tree is very valuable for many purposes, while that of the white elm is almost useless. The English elm is a very valuable street tree, and, at the West, we believe, it will yet take a high rank as a timber tree, and be extensively planted for its economic uses.

The hard, or rock maple, *Acer saccharinum*, is very properly a favorite street-tree, although it is of slow growth. It is one of the most durable of trees, possesses a heavy foliage, and forms a large, erect, symmetrical head. In the fall the leaves assume brilliant scarlet and crimson tints, and remain in this condition longer than those of any other of our native trees. This tree is the crowning glory of our autumn landscapes. The timber is of the highest value, being characterized by great strength and density.

The silver-leaved maple, *Acer dasycarpum*, is very extensively employed as a street-tree, for which purpose it is adapted by its rapid growth, large, spreading head, which, in some old trees, takes a form somewhat like the white elm, and by its handsome, deeply-cut leaves that are silvery on the under side, and which are supported by long, slender petioles, allowing them, like those of the poplar, to be swayed by the slightest breeze. The timber is not strong, and the branches are often split or broken by the winds. The trees are greatly improved in form by frequently cutting in the branches, or heading back, during the early years of growth.

The Norway maple, *Acer platanoides*, a European species, is comparatively a low and broad-headed tree, with large leaves, bright and shining on both sides, and the foliage quite dense. It grows somewhat slowly at first, but when well established makes a very fair annual growth. Its handsome foliage and broad-spreading head make it an excellent street-tree.

The European sycamore maple, *A. pseudoplatanus*, is a beautiful tree, with a spreading head and dense foliage. The leaves are large and handsome. It thrives well in this country and is a valuable tree for the street, rising from fifty to seventy-five feet high. It grows more rapidly than the sugar and the Norway maple.

Both the butternut and the black walnut are often found on country road-sides, where, on hot and sultry days, they arouse the liveliest emotions of gratitude in the breast of the weary traveler oppressed by the noon-day sun. But they have never been much employed as street-trees, on account of their thin foliage in their earlier years, and, in fact, it never becomes very dense. Both the fruit and the wood of these are quite valuable, and occasionally a spot may be found where one can be planted to advantage on the street.

The American linden, or bass-wood, is a handsome street tree, and the European linden, *Tilia europæa*, is still finer, but both of them are so subject to the attacks of an insect, the *Saperda celtidis*, whose larva bores into the trunk of the tree, that they are now seldom planted as street-trees. They are well adapted for this purpose, and the fragrance of their bloom is almost proverbial. It is to be regretted that they should have so invidious and persistent an enemy.

The horse chestnut has been much used as a street-tree, and, when in bloom, it is one of the most beautiful objects in the whole vegetable kingdom. Its leaves push out early in spring, but decay early in fall, and it makes much litter when it drops its burrs and nuts in autumn. It is most too compact and round-headed for shade. It deserves an occasional place, but not general use as a street-tree.

The variety of elms for street purposes may be increased by the use of Clemmner's elm and the Cornish elm, both of which are varieties of the English elm, *Ulmus campestris*. A species known as *U. doerri* is also, well adapted to the purpose. All of these last-named elms are still scarce and high-priced, whereas any of the other trees described are plentiful and cheap.

The conditions are necessarily such that a tree planted in the street cannot appear to the best advantage, its beauty is subordinated to its use, it must be trained to branch high in order to be out of the way of pedestrians and vehicles. Private lawns and public squares and parks furnish the opportunity of producing perfect and unutilized specimens of trees. The examples of extensive parks furnished by our largest cities cannot possibly be imitated by the smaller towns and villages; but because an area of hundreds of acres cannot be maintained as ornamental ground, there is no reason why fifty, or twenty, or ten, or two acres may not be. There is no village but may have its village green, with its trees and shrubs, its walks and seats, and retreats, and whatever may add to the pleasure and convenience of those who shall resort to it for pleasure and health. There is a great work to be done in all parts of the country in providing these places of public resort, whether as small or larger places, and designated as greens, or squares, or parks. Our medium-sized cities have, usually, several squares of two or three or five acres in extent, and these add greatly to the beauty, comfort, and health of the citizens; some of the best villages are similarly supplied, but, as a rule, country villages have made no provision in this respect. This is an oversight and should be remedied; a village of only a thousand inhabitants would experience great advantages and comfort in a well-planned, well-planted, and well kept pleasure ground. The expense of land in small villages is comparatively little, and there is no reason why public grounds may not as well be maintained in such places as in larger ones.

We wish that our readers might be leaders of public opinion in regard to this matter in those places where there

are no public grounds. The advantages of establishing such places of resort are so apparent that a little energetic work in some communities will be sure to be crowned with success.

Possibly, in the future, something more may be offered on this subject, together with illustrated plans of squares and park grounds of small and medium size.—Vick's Magazine.

PHOTOPHONIC SELENIUM RECEIVERS.

THESE receivers are made by taking two slips of brass 1-10th mm in thickness, 0.01 m. wide, and from 1 to 5 meters in length. They are separated by two slips of parchment paper of about 0.13 mm in thickness. The whole is rolled up in a coil as tight as possible, and kept together by means of two pieces of wood held by two screws. The two surfaces are polished with the file. The apparatus is then heated in the sand bath to the temperature at which selenium begins to melt. A stick of selenium is drawn along its surface, and the layers receive the characteristic slate color indicated by Bell. These receivers are continuous and have the same properties as the ordinary discontinuous receivers, plane or cylindrical.—E. Mercadier.

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